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Not to be folded or roughly handled

*Proceedings of the Madras Government, Public Works Department,
22nd January 1869.*

No. 398. Read the following Circular from the Government of India, Public Works Department, (Military Works,) to the Local Governments and Administrations, dated Simla, 30th October 1868, No. 92:—

I am directed to forward, for information and guidance, copy of a Report by Dr. Macnamara, the Chemical Examiner to Government, dated 18th December 1867, on the analysis of potable waters of Cantonments in the Bengal Presidency, together with a copy of the orders* of the Government of India, in the Military Department, thereon, and to request that the general suggestions and recommendations contained in pages 15 to 18 of the Report, which appear to be very valuable and practical, may receive the most careful attention.

(Signed) C. H. DICKENS, Colonel, R. A.,
Secy to the Govt. of India.

Copy forwarded for information to the Governments of Madras and Bombay, in the Public Works Department, to the Military Department, the Quarter Master General, the Adjutant General, and the Sanitary Commissioner with the Government of India.

(Signed) J. W. ALEXANDER, C. E.,
Offg. Assist. Secy. to the Govt. of India.

To the Secretary to the Government of Madras, Public Works Department

From the Professor of Chemistry, Bengal Medical College, to the Secretary to the Inspector General, Lower Provinces, dated 18th December 1867.

I have the honor to report upon the work of the Medical Officers who were engaged during last April, May, and the early part of June, in analysing the potable waters of the Military Stations named in the margin, and I have added the reports which I have received on the analyses made during the past rains in the eight last-named Stations. Owing to the absence, on sick leave, of Dr Lackersteen, no further progress has been made in investigating the water-supply

Peshawur	Bareilly
Ferozepoor	Lucknow
Umballa	Allahabad
Delhi	Cawnpoor
Agra	Dinapore
Morar	Hazareebangh
Saugor	Fort William
Jubbulpoor	Dum-Dum
Meerut	Barrackpoor
	Chinsurah

of the Central Punjab Stations. Dr Murray Thomson was prevented by his duties at Roorkee from visiting the Hill Stations during April and May. He is, however, now engaged in the work, but as it is highly desirable that the waters of those Stations, should be examined before the commencement of the rains, I beg to suggest that one of the Medical Officers, who have had the necessary experience elsewhere, should be deputed to the Hill Stations during the next hot dry season.

Dr Center, who was to have been employed in analysing the waters of Campbellpoor, Rawul Pindie, and Peshawur, was able to accomplish the work at the latter station only, for, owing to the outbreak of cholera during May, his services were urgently needed in the detached camps. Dr Orton, who was detained in Lucknow by his duties as Officiating Sanitary Officer of that city, was unable to visit Fyzabad and Seetapoor, and Dr Jameson was prevented by his duties at the Doyal Jail from proceeding to Benares till long after the rains had set in, his report, therefore, upon the waters of that Station will appear in the report upon the autumnal analyses. These and other changes in the analytical staff have interfered considerably with the progress of the work. Still a great deal has been accomplished, and I feel confident that reports of even greater value, and more completely reliable, than those hitherto sent in, will be obtained when the exigencies of the service

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allow of the continued re-employment of those Medical Officers who evince taste and ability for this very special duty.

The value of a water-supply report depends not solely, or indeed chiefly, on the great accuracy of the analysis it includes, but mainly upon the truthfulness of the picture it presents of the condition of the water-supply of the station, pointing out where it is liable to contamination (either as a whole, or in any of its separate sources), and how far it is capable of improvement. But to ensure such a report, minute and well directed enquiry is needed, and enquiry of a nature which Medical Officers new to the work and fresh from Home will necessarily find a difficulty in instituting and it is evident from the experience of the two past seasons that, as might *à priori* have been expected, the analyses differ very much in their aptitude for this special work, though all exhibit an amount of technical knowledge that would not have been looked for in Officers who entered the service before the establishment of the Netly course. No doubt these gentlemen receive the best course of training, it is possible to give them short of an independent course in a working Chemist's Laboratory, still I fear that not a few of those who are thus trained will fail when thrown upon their own resources, just as many a man who has passed in Anatomy fails altogether as an operative Surgeon. My experience as a teacher of practical Chemistry is, that very few individuals out of a large class have the qualities necessary to make them successful analysts. Very few will be found to have really any taste for chemical analysis, many students appear incapable of recognising any error, or source of error, which accidentally obtrudes itself in even the simplest processes, while if error is possible, they fall into it; and other students wanting in perseverance and exactness, readily content themselves with an imperfect result. Other deficiencies might be mentioned which must give rise to failure when such students are thrown upon their own resources, especially if they have to employ processes and apparatus to the use of which they have not been trained. If a man has a taste for analytical Chemistry, it is highly probable that he possesses the natural qualifications for that work, and he will certainly take pains, when opportunity offers to become proficient in it, and I therefore think the plan pursued in regard to one batch of Assistant Surgeons, which arrived at Calcutta, might very advantageously be pursued with others, and that volunteers for employment on the analytical staff should be called for, and that those gentlemen who register their names should be preferentially employed when the exigencies of the service permit of any selection being made.

Apparatus—The twelve sets of Chemicals and Apparatus indented for from England reached Calcutta in time for distribution in April last. The apparatus was generally well chosen, and well adapted for the work, but the boxes appeared to be of unseasoned wood, and screws might with advantage have been more freely used, in the place of glue, in fixing the partitions. Unfortunately the most important piece of apparatus in each set, namely, the balance, is decidedly inferior, clumsy, roughly made, difficult to get into good working order, and very apt to give wrong indications unless used with the most extreme circumspection. I received many complaints from every one of the analysts regarding the want of accuracy in the balances, and it is on that account that I have not laid stress upon the reported results obtained by ponderal analysis in any case in which very accurate weighing would be required to establish them. I have circulated among the analysts most minute directions for using the balances, and I hope that, by the aid of these instructions, inaccuracies may, as far as is possible, be avoided, but I am decided in my opinion that the balances are unfit for their intended purpose, and it will be most satisfactory to learn that the balances have already made for their re-placement has been sanctioned.

I commence the report upon individual stations with that on Peshawur—the waters of which were examined by Dr. Center in May and August. Dr. Center reports as follows—

“The water-supply of the Station of Peshawur is from two sources—from wells, and from a cutting from the Bara River, made by the Sikhs

Sources of water supply

“The native troops use the stream water only, the British troops employ both sources. The wells are very deep as the station lies on a long ridge of low elevation, sinking away towards the east, the water-bearing stratum is not far from the surface. The ground towards the east of the station, from about the Lines of the 13th Bengal Cavalry towards the Fort and the city was a graveyard, and an extremely crowded one. On simply raising the ground with a stick, fragments of bones

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are seen. On enquiry of Natives and Europeans as to whether the west and greater part of the station was a grave-yard or not, conflicting accounts were received. From trials of the soil, it seems most probable that there were small isolated grave-yards of one or more hamlets.

“The stream flows from west to east through the station, dividing laterally into two branches. Secondary streams run off into Regimental tanks, others irrigate the compounds, others flow through the bazaars. The water is liable to be polluted on the main, or sometimes even more on the secondary streams. It is notorious that they are polluted, in consequence of the careless and disgusting habits of the natives. To guard against this, the tanks are usually filled at night. It is recommended that main streams should be protected by a fence or a mud-wall. The Regimental Authorities should see that the streams going to the tanks be as short and well protected as possible.

“This stream enters the station from the west and flows through it. Cuttings are made to the Regimental tanks as it passes the Lines, others are made through the compounds for irrigation, and for filling smaller tanks, others run through the bazaars. Thus it supplies water for three purposes, for drinking, irrigation, and for carrying off sewage. The soil, &c. of the station is removed by carts.

“About the middle of the station the main stream divides, the two branches acting as main streams, and giving of secondary branches. The water is made to run through different parts of the station at different hours if the stream is low.

“The main stream is quite unprotected by walls or otherwise. It flows through compounds, and at the road-sides laterally, natives' houses are built close beside it, and cattle are kept close to it in various places. It is quite common to see natives washing their bodies and utensils in it. A pucca drain is made from the wash-houses of the 77th Regiment direct to the main stream.

In a letter to me, Dr. Center writes—“Further, as an instance of how the water might be polluted, while in company of another Medical Officer, I observed a native suddenly taken ill, vomiting within a few feet of the bank of the main stream in the 42nd Lines.”

I find the following notice of the water-supply of Peshawur in a report on the epidemic visitation of cholera in the 93rd Highlanders by Dr. Munro, the Surgeon to the Regiment, published in the Sanitary Report of the Army Medical Department for 1862—“The Bara supplies the station and city with water for all purposes of domestic use and irrigation, and its waters are led into Cantonments through artificial channels that traverse every street, pass close to all public buildings, and run through every garden or compound. These channels are simply ditches, and, in most instances, on a plain higher than the foundation of the houses, they are neglected, dirty, frequently choked up with mud, which is often exposed for hours and days, when the water is cut off from one locality, and turned off in another direction. There are miles of these ditches within Cantonments, and one of the largest and dirtiest runs close past the Barracks and Hospitals which were occupied by the 21st Hussars, and also close past the barracks occupied by the 93rd, its bed being higher than the foundations of the barracks. The Artillery Barracks are almost enclosed by such ditches. A considerable stream from the same river flows through the city of Peshawur which the inhabitants use for domestic purposes, and into which all kinds of filth are thrown, and which appears to act as the main surface drain of the city.

The stream itself was examined by Dr. Center two miles above the station. He found the water hard, and containing a considerable quantity of oxidisable organic matter, Ammonia and Nitrous Acid were also present. The water contained no large amount of dissolved constituents, and if the stream could be kept clean and unpolluted, it would yield a very fair drinking-water. Dr. Center next examined the water taken from the tank which supplied the 77th Regiment. This tank is filled by means of a water-course about 20 yards in length, connecting it with the main stream. Just below the Barrack yard is a Corn-mill, turned apparently by the stream, but, however this may be, the vegetable refuse from the mill is thrown upon the ground near the banks of the stream, and there decays. Until lately, (indeed at the time when Dr. Center commenced the examination of the Station waters), the drain from the Regimental Wash-houses opened into the stream just below the mill, and added its quota of pollution to the waters. From analyses it appeared that

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the tank water resembled that of the stream higher up in its course, but contained Nitric Acid in addition to Ammonia and Nitrous Acid and an increased quantity of chlorides

The water from the tank belonging to the 45th Native Infantry was next examined. The tank is fed by a leader from the main stream, and also by the drainage of the parade-ground, it is sheltered by trees, the dead leaves from which fall into it, and at the time of Dr. Center's visit, it was covered by a mat intended for its protection, but old and useless, and partly immersed in the water. The water of this tank resembled that of the tank belonging to the 77th Regiment, but contained more oxidisable matter, and a larger amount of common salt.

The tank of the 13th Bengal Cavalry is connected with the stream at a point still lower in its course, this tank is reported to be well kept, but connected with the stream by a channel which meanders amongst native houses, and in close proximity to the place where the horses of the Regiment are stalled. The water closely resembles that of the tank of the 45th Native Infantry.

The Hospitals of the 42nd Royal Highlanders and of the Artillery are supplied from Mackeson's well, the water of which is considered very good. The well is 100 feet deep, and yields an ample supply of water, it is imperfectly protected by a roof supported on four pillars. Apparently, the ground about the well is carefully guarded, but the mud lately removed from the well should not have been placed over the surface of the surrounding enclosure. The water, as shewn by its analysis, may be considered a fairly good specimen of well water, it contains traces of Nitric Acid and Ammonia, which may have a questionable origin, if, as I have been lately informed, the space where the well is, was formerly a grave-yard.

The Artillery are supplied from a well about one mile north of the station. This well is only eleven and a half feet deep, yet it always yields an abundant supply of water, for the level of the land falls considerably towards its locality, and surface springs occur in the neighbourhood. There are old graves all around the well, and the place is a favourite resort for dhobies, the practice of whose craft had, at the time of Dr. Center's visit, resulted in the formation there of numerous stagnant pools of water. A fakir who lives at one of the neighbouring tombs, and is apparently the guardian of the place, reported well of the water, and probably would continue to do so, even though he understood the purport of the Nitrous and Nitric Acids and Ammonia which the water contains. What with graves, dhobies, and the visits of unwholesome pilgrims who resort to the fakir's, the well must be a perilous one to those who are compelled to drink its water.

The Jail well is about 50 feet deep, it is situated in the Jail-yard; water is raised from it by a Persian wheel, and flows from a spout into a small masonry cistern filled with stone and charcoal, and thence into a second similar receptacle, but the bheesties, possibly with a right appreciation of the value of the stones and charcoal fill the water-bags from the spout. Ghurrahs for dyeing purposes are stuck in the ground close to the well, and the waste water from the well, together with the refuse from the dyeing processes, runs to a neighbouring plot of grass where it stagnates and emits a most offensive odour. The Jail is built on the site of an old grave-yard. The water of the well is very bad, and the prisoners ought not to be condemned to drink it.

The water from the well in the Fort is very salt and bad, but it is used only by native workmen employed there. Water for the use of the guard is brought in by bheesties from a surface spring at the head of a drain in the neighbouring wheel.

The water-supply of Peshawur is "generally considered wholesome." If it is so, Dr. Center cannot have correctly described it, but I suspect his description is fairly drawn, and I cannot but think that measures are urgently needed to supplant the present water-supply, either by means of an artesian well, or by bringing water into Cantonments by means of a pipe or closed aqueduct from the Bara river.

Ferozepoor.—Dr. D. W. Palmer visited the Station, and examined the water-supply, during last June, the weather at the time was fine, with occasional dust-storms, temperature 97° in the shade.

The Cantonments are entirely supplied with water from wells, which pass down through the sand. So far as the wells, have been sunk (about 50 feet), sand only has been met with. The wells yield a plentiful supply of water, and the supply does not notably diminish during the hot weather.

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None of them, at the time of Dr. Palmer's examination, contained much water, in general only four or five feet, and I, therefore, conclude that they are quickly re-filled by water percolating the soil.

The water of the station is generally considered wholesome, but it is apt to contract a peculiar smell after a dust-storm, the cause of which is not explained. Dr. Palmer believes, as the result of his analysis and enquiries, that, with the exception of the water of the Artillery well, the well water of the Cantonments is of good quality. Unfortunately his analyses are in some points defective, and further enquiry is, I think, necessary before a positive opinion can be pronounced regarding these waters.

The European Infantry are chiefly supplied from three wells. One of these is in the Soldier's gardens, surrounded with trees, Dr. Palmer notices that it required a cover to prevent dead leaves falling into it. The physical properties of the water are reported good, excepting after a dust-storm, when the water acquires a disagreeable smell. The water contained a moderate amount of dissolved constituents but the permanent hardness is very great, 9° on Clarke's scale if the report is correct. Another of the three abovementioned wells is No. 81, it is not far from the Soldiers' gardens, and its water resembles that of the well just referred to. The other of the three wells, No. 79, is situated in the European Infantry Hospital compound, and close to the hospital buildings. This well is in the neighbourhood of the other two, about equi-distant from each of them, yet its water contains very much more dissolved constituents, more oxidisable organic matter, and double the amount of chlorides. I suspect contamination has ensued from its proximity to the hospital buildings including the Cook-house.

The Artillery are, as appears from Dr. Palmer's account, supplied by two wells, one No. 73 in the Lines, the other in the Hospital compound. Unfortunately the reported analyses are very defective, but in both cases the waters appear to be very hard, and to contain a large amount of oxidisable organic matter, both waters also contained a large amount of dissolved constituents, the water in the hospital well nearly 57 grains to the gallon, that belonging to the well in the Lines double the amount. Dr. Palmer is unable to account for the large amount of dissolved constituents in the water of the last mentioned well, but thinking it a very bad water, he wrote strongly recommending the Commanding Officer to discontinue its use for his men, and to employ in its stead the water from a well in the neighbouring Native Infantry Lines. At the time of Dr. Palmer's visit, the Artillery had been driven into camp by an outbreak of cholera.

The Native Infantry at the station are chiefly supplied by two wells, whose water resembles that used by the European Infantry. The nearest of these wells is about 700 yards distant from the well in the Artillery Lines already referred to. Dr. Palmer considers the water in the well of the Native Infantry Hospital the best in the Station, it contained, at the time of his analysis only 15 grains to the gallon of dissolved constituents, but it contained Nitrous Acid, and a very large amount of oxidisable organic matter.

The only other well examined by Dr. Palmer was that in the Fort, its water closely resembled that of the north well in the Native Infantry Lines, containing a slightly larger amount of oxidisable organic matter.

I gather from Dr. Palmer's report, that there would be no difficulty in supplying Ferozepoor with a plentiful supply of fair well-water, and the station is in this respect far more fortunate than Umballa, no doubt because of its proximity to the Sutlej, the present wells appear to be badly situated, being all adjacent to buildings. Better water should be provided for use in the Artillery Lines and Hospital, and I cannot but think it would be advisable to provide another well for the use of the European Infantry Hospital at a greater distance from the hospital buildings.

Umballa.—Dr. D. W. Palmer examined the water of the Umballa wells in May and June; the weather at the time was hot and dry, only very general inferences can be drawn from Dr. Palmer's analysis.

The troops at the station draw their supply of water from wells which are for the most part dug in or near the beds of the two branches of the Tangree Nullah between which the Cantonment is situated. The Tangree is not a perennial stream, and though in the rains it may suddenly become filled by a great flood of water, becomes quite dry after a fortnight's cessation of rain. One elbow of the nullah touches the northerly angle of the Cantonment, and here are the Artillery or Tangra

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wells, another elbow of the nullah approaches the east corner of the station, where are situated the more recently constructed Tangree wells. Between these two sets of wells, a distance of about three miles, stretches an aqueduct covered only in a part of its course. From the Tangree wells the aqueduct runs along the northwest face of the station in front of the Artillery and Cavalry Lines, it then bifurcates, enclosing the European Infantry Lines, and finally passing in front of the Native Infantry Lines, terminates at the angle of the station.

The aqueduct obtains its chief supply of water from the Tangree wells, and receives a reinforcement from the Tangra wells, the water is raised from the wells, Persian wheels worked by bullocks.

The Native Cavalry Lines are situated in the centre of the north-east front of the station, they are not, however, supplied with water by the aqueduct, but by detached wells.

The Artillery are supplied by their own wells near the bed of the Tangree Nullah.

The European Cavalry and Infantry are supplied by wells, or more probably cisterns, which are filled by branches from the aqueduct, these branches and cisterns themselves are open. A cistern is placed opposite each barrack.

The Native Infantry are supplied partly by the aqueduct, and partly by wells in their Lines, but as the water in the aqueduct falls short in the hot weather, the men are at that season chiefly dependent upon detached wells for their supply of water.

The hospitals of the European Cavalry and of the Artillery are supplied by detached wells, the cistern of the European Infantry Hospital is filled by a branch from the duct, the Native Infantry Hospital has its own well.

As regards the properties of the water drawn from the Tangra and Tangree Nullahs, I gather from Dr Palmer's analysis that they are much alike, and of very fair quality, not containing more than 25 grains to the gallon of dissolved constituents, not injuriously hard, and not containing more oxidisable organic matter than is usually found in properly situated shallow wells. Unfortunately the supply which these wells yield is very limited, and they run dry if water be pumped from them continuously for many hours.

It did not occur to Dr Palmer to analyse the water in the cisterns, but he examined the water in the state in which it is drunk in the European Infantry and Cavalry Barracks, both of which are supplied from the same source. Yet if Dr Palmer's analyses are correct, the water of the Cavalry Barrack contains almost twice the amount of dissolved constituents present in the water from the Infantry Barrack, both contain a very large amount of readily oxidisable organic matter, which Dr Palmer ascribes to the water entering the cisterns through uncovered ducts; but he makes no report on the state of the cisterns or barrack filters, and the fault may be in them.

The water in use in the European Infantry Hospital is also taken from a cistern supplied by the aqueduct, but no report is made upon it.

The Artillery Hospital Well is in the Racquet Court. It yields but a limited supply of water daily running dry by noon in the hot weather, the water holds in solution a considerable amount of saline matter, and is much harder than the water of the aqueduct.

The Cavalry Hospital Well is within the compound, about 20 yards from the hospital buildings, its water contains a large amount of dissolved constituents, about 50 grains to the gallon, very much oxidisable organic matter, traces of Ammonia, and some Nitric Acid, it is, I suspect, contaminated, owing to the circumstances of its position.

The water in the detached wells used by the Native Troops contains much more dissolved constituents, and is much harder than the aqueduct water,—the water of the Native Cavalry Hospital is described as having a brownish color, and an earthy taste. The well in the Native Infantry Lines deserves particular notice, as its water is used by the sepoys when the supply from the aqueduct falls short. The water is very bad, containing as much as 92 grains to the gallon of dissolved constituents, its use is said to cause diarrhoea.

I believe it is an admitted fact that the water-supply of the Cantonments of Umballa is very defective, and that for the city, both very defective and very bad. Many reports have been made upon the subject, especially by a Committee of Officers appointed in 1851 to enquire into the matter, and again, in 1863, by Captain Crofton, R. E., Superintendent of the Sutlej Canal Survey.

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In consequence of these reports, the Tangree wells were opened in 1865, and they have greatly added to the available supply of water for Cantonments, but the supply is still deficient, and in the city and its neighbourhood the want of an ample supply of water is very much felt. To meet the deficiency, three schemes have been proposed to bring water by means of an aqueduct from a point on the Guggur river, 21 miles distant from Umballa, or to bring water into the stations from two small lakes situated in the hills, about 22 miles distant from the station, but the cost of carrying out either of these schemes would be very great. The third plan is to construct an artesian well. As it seems most probable from a consideration of the situation of Umballa that an artesian boring would be successful, and would, at a comparatively small cost, furnish an adequate supply, this plan should, it seems to me, first be tried. Another argument in favor of a trial being given to this last plan is that, whether the boring at Umballa should, or should not, prove a complete success, the instruments and work-people might be employed in other stations where an artesian well would be an immense boon.*

Delhi—The Delhi waters were examined for the second time by Dr Sheppard in May and June, and his report, which I now forward, fully describes their state at the time of his visit. I need only notice his remarks upon the waters which are used by the European Troops. The river water still maintains its character as the best potable water in the station, and in my opinion no other should be used by the troops in garrison. Dr Sheppard does, indeed, speak favorably of the water of the Puthur-Ghatti Well, which is used by the troops in the Fort, but I hold strongly to the opinion that the troops ought not to draw their supply of drinking-water from an unguarded public well, and if it is worth the expense and trouble to bring water from the river for the supply of the Barracks and Hospitals, I think the same water might be supplied to the European Troops in the Fort also, at any rate for drinking purposes. If, however, the use of the Puthur-Ghatti Well is continued, Dr Sheppard's suggestions for its improved conservancy should be strictly attended to.

It is very evident from Dr Sheppard's Report that an efficient system for the filtration of the drinking-water at Delhi is much required, and settling tanks, which need not be of great size, should also be provided for use in the rains when the river water is rendered milky by the presence in suspension of finely divided clayey matters, but these settling tanks need be used only in the case of water designed for the drinking supply of the troops.

The following are Dr Sheppard's remarks upon the principal wells, and upon the drinking water in use by the troops—

“The Puthur-Ghatti Well is situated close to the termination of the Western Jumna Canal. It is not overhung by any trees, to the east is a large mound composed of the debris of former buildings which were razed to the ground in order to make way for Railway works, to the south of the well is a rather large puddle of water and mud, the water being derived from the canal leakage, and from the spillings after drawing up the well water. There is no arrangement for draining this.

“The platform of the well is too small, and the spilled water may either fall at once into the well, or soak into the earth around the masonry. On the whole, the construction and conservancy of this well are of the worst description.

“The water, when examined in 1867, contained a smaller quantity of saline and combustible matters than it did at the end of the rainy season in 1866. The Nitric Acid had also decreased.

“This is a most important water source, inasmuch as the supplies for the Artillery and the European Hospital are drawn from it. Owing to the disadvantageous sanitary condition of the adjacent ground, and the imperfect construction of the well, the water is not of good quality, but from the two analyses which have been made of it, I am of opinion that it is one of the best well waters in intramural Delhi, and further it is, I think, possible to improve this water a little by raising the masonry of the well 3 feet, and making a platform at the top of it 6 feet in diameter, the construction of an apron about 4 feet wide, raised 1 foot above the level of the ground with proper ridges, and a drain to carry away the spilled water into the canal lower down, broken ground to the east should be levelled and dressed, and no encroachment of buildings should be permitted.”

* Dr. Sheppard is now employed in analysing and reporting upon the Umballa waters.

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Khyrattee Gate Well—This is situated in low ground, the shaft has been sunk in the sandy bed of the Jumna at a little distance from the city wall, the level of the ground inside the wall being several feet above the river bed. At this season of the year, there is no stream near the well, but in the rainy and cold seasons of 1866, there was one within 100 or 120 yards.

The supply of this well is not depended upon the filtration from the river, for the water exhibits such a marked difference in composition as characterised by the large amounts of total solids, combustible matter, and Nitric Acid, but it is highly probable that the constitution of the water may be influenced in some degree by the proximity and fullness of the stream which, in the rainy and cold seasons, runs under the city wall.

The presence of such a large quantity of combustible matter and Nitric Acid in this water is strongly suggestive of the entrance of the city drainage by percolation into this well at all seasons of the year.

The amount of total solids, combustible matter, and Nitric Acid has increased since the cold season of 1866.

The chemical composition of this water shows that it is unfit for drinking purposes. Notwithstanding its bad quality, a large section of the Native community, many Sepoys of the 25th Regiment, Punjab Native Infantry, and several European residents of Duriyagunge, drink it. The Natives believe that it is Jumna water, and the Europeans think the quality is excellent. I drank this water for some time in 1866, without being fully aware of its badness. Its effect on me was the production of dyspeptic symptoms and a tendency to diarrhoea. As soon as I had ascertained by analysis the quality of the water, I ceased to use it.

The Medical Officer of the 25th Punjab Native Infantry says—"The canal water is of fair quality, but that obtained from Khyrattee Gate Well is bad. I have observed an increase in the number of Delhi sores when the canal supply was stopped, and also a tendency to spread in those sores that were healing."

Delhi Gate Well—This has been constructed in high ground inside the city wall. It is situated on the side of a much frequented high road, on either side of which is a row of houses, a Peepul tree spreads its branches over the well. Around the well shaft is a masonry trough to catch the spilled water, but there is no drain to carry it off, at times the collected water is of a dirty brown color, and is offensive to the smell, perhaps from the dirt and animal matter derived from the bodies and clothes of those who bathe on the well platform.

Since the analysis of 1866 was made, there has been a great increase of total residue, combustible matter, and Nitric Acid, the water now contains over 59 grains per gallon of earthy salts, of which 41 grains existed as Nitrates, Sulphates, and, perhaps, as Chlorides in their most objectionable forms. The permanent hardness arises from 5.07 to 7.73 degrees of Clarke's scale.

This water is unfit for drinking, it is of worse quality than that obtained from the notorious Cholera-producing well in Broad Street, Golden Square, London, and, at this season, it surpasses some of the very worst of the shallow well waters analysed by the late Dr R. D. Thomson. Of the 44 analyses made by him of the waters from the Marylebone Wells, in no instance was there so large a total residue, and only four waters contained a greater quantity of combustible matter than the Delhi Gate Well supply.

The old Cantonment Well is sunk in a large plain, formerly the parade ground of the Native Infantry. It is at a considerable distance from any trees or buildings, and far away from any sources of contamination, the sides of the well are covered with a luxuriant growth of *Algæ* or *Confervæ* (I am not certain which) below the water-level. There was no vegetable growth in this well in 1866.

The total solids found in this water have slightly increased, and the amount of earthy salt has considerably decreased, the total and permanent hardness have both diminished, and the combustible matter is present in slightly larger quantity than it was in 1866.

The deep wells examined were only two, viz, the Indaree and the Kazee-ka-houz.

Indaree Kooah—This is situated in the Kuroojapool Bazaar close to the roadway. It is covered by a large Peepul tree, and is surrounded on three sides by houses, numerous pigeons live in the well, the water is much esteemed by both Hindoos and Mahomedans.

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The quantity of total solids, combustible matters, and earthy salts, as ascertained by two analyses, made at different seasons of the year, are very moderate and uniform in this water, and although it contains a rather large amount of Lime and Magnesian Salts, viz, 23.50 grains per gallon, more than one-half of this quantity exists in the most harmless form, as Carbonates of Lime and Magnesia dissolved by an excess of Carbonic Acid.

The uniformity in composition of the water at different seasons, and the depth of water in the well, lead to the supposition of the supply being obtained from one of the lower water-bearing strata.

Pigeons live in this well, and although not productive of much harm, they cannot possibly do any good, their absence would be preferable to their presence.

The *Kazee-ka-houz* Well is in the heart of the city, situated in a triangular space formed by three roads. It is surrounded on all sides by houses which are densely populated within one angle of this plot is the well, and at another, is a masonry tank which is now regularly filled with canal water.

Last year, the water from this well was only partially examined. The total hardness was then 9.84°, and the permanent hardness 9.0° of Clarke's scale, it contained about 45 grains of Nitric Acid per gallon. Ammonia and Nitrous Acid were found in it, the total residue and the combustible matter were not then determined.

An analysis according to the scheme was made this year. The total hardness was 4.2°, and the permanent hardness 4.03° of Clarke's scale. Only one grain of Nitric Acid per gallon was found, and a small quantity of Ammonia and Nitrous Acid. From these sparse data, it is evident that this water has undergone an astonishing change of composition since last year.

In 1866, the distribution of canal water over the city was limited, as the aqueducts were being repaired or altered, the tank by the side of this well was empty, and at this time the water in the well must have been derived from drainage.

After the completion of the repairs, &c, the canal water again flowed in its former channels, and some wells, which were known to be very saline, were filled up by flooding them with canal water, allowing as much to run in as the level of the supply channel would allow. The pressure of such a large bulk of water appears to have caused rapid percolation into the earth, and, after two or three days had elapsed, the water in the wells usually resumed its former level, and it was found to have lost its saline taste, or, if not entirely deprived of it, a repetition of the treatment with canal water has usually, it is stated, attained the desired result.

I have not witnessed the treatment, my information was obtained orally from a Canal Officer and from Natives.

On drawing water from the *Kazee-ka-houz* Well this year, I observed that it was slightly opalescent, whereas in 1866, it was bright and colorless. I enquired how this change had come about, the people replied that their pet water had been spoiled some six weeks previously by the well being flooded with canal water, which had been run in by order of the Municipal Commissioners. The masonry tank was at this time full of canal water.

The *Kazee-ka-houz* water is now nearly similar in composition to that of the Jumna. The sample analysed contained, however, slightly less of total residue, and about twice as much combustible matter, also a small quantity of Nitric Acid, Nitrous Acid, and Ammonia; these did not exist in the Jumna water. The addition of the latter impurities and the increase of combustible matter is readily explained, as the people, who live on the canal banks, wash their clothes and bodies, and bathe, and water cattle and horses in the stream.

The rapid rate at which the water flows in the canal causes erosion of the banks, so that the water on reaching Delhi has a dirty Ochre color from the finely divided clay which is held in suspension.

In spite of the assertion made by some of the people that the water of this well had been spoiled by the introduction of canal water, I observed that many persons were drawing it. Owing to its opalescent tint and flat taste, it was doubtless far less inviting and pleasant than the clear, brisk, and agreeably tasted water which the well contained in 1866, the pleasant qualities which it then possessed were derived from the presence of nitrates, and from the large quantity of "Carbonic Acid Gas."

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Her Majesty's 79th Highlanders has paid great attention to the filtration of water, in fact, greater care or solicitude for the efficient performance of this important process could not have been manifested by any corps

I have, on two different occasions, taken samples of filtered water from the Barrack-rooms and Hospitals occupied by the Artillery and the 79th Regiment, the water was taken from the same filters in both instances, the results are given in the Appendix

During the hot season (June), the filters simply separated a portion of the suspended matters, and at the same time they added organic matter to the water in a small but appreciable quantity

After the commencement of the monsoon, the water was examined for the second time, the results of filtration were variable, in five instances the organic matter had decreased, in one instance it had been increased, and in one, it was present in the same quantity that existed before filtration

No dependence can be placed on filters which give such variable results, the construction and arrangement of them is so unscientific that little benefit can be expected from their use

It may not be out of place to point out the shortcomings of the present filtering apparatus. Three earthen gurrals are insufficient, four are required, for since one vessel is used as a receiver of filtered water, the remaining two must form the filter, one containing the charcoal and the other the sand, or the sand and charcoal are mixed together, and placed in the middle gurrul, and the upper one remains as the receiver of the bulk of water from the mussuck. Both arrangements are objectionable, for if the charcoal be placed in the upper vessel when the water is poured in, part of the charcoal is disturbed and floats, and the water does not pass through a compact layer of charcoal, but it passes between the fragments, and little, if any, good results, if, on the other hand, the charcoal and sand be mixed together on cleaning the filter, it is impossible either to separate the charcoal which requires to be re-heated to burn off the organic matter which has been absorbed, or to wash the sand thoroughly before re-placing it

A good filter might be made of galvanized sheet-iron, with sand, charcoal, and vitrified brick packed in layers, supported by intervening diaphragms of metal, each being pierced by holes adapted to the nature of layer of the filtering medium which it is intended to support, in the hot season these vessels might be surrounded by a felt or other non-conducting jacket

The advocates for the use of porous gurrals as filters, maintained, that the evaporation from the surface of the vessels cools the contained water to some extent two conditions are necessary for this, *viz*, permeability of the pores of the vessels, and movement of the air in contact with them. In Barracks, neither of these conditions exist as a rule, for the pores of the gurrals are soon choked, and new vessels are seldom supplied, and owing to the position which the Filter Stands usually occupy in a corner of the verandah, scarcely any current of air reaches them, in many instances, the wind before it could reach the filters would have to describe the half of a circle

The water used by the troops at Delhi during the past year has been obtained from two sources, *viz*, the River Jumna and the Putthur-Ghatti Well; the 2-25th Royal Artillery has used the water from the latter source, and the European Hospital also obtains its supply of water from this well

The Wing of Her Majesty's 79th has drunk and cooked with river water since arrival. After the monsoon set in, the quantity of silt in the river water was so great, that its use was discontinued temporarily. Owing to the want of iron-tanks in which the water could be allowed to remain at rest while the suspended matters subsided, the filters became choked, the water which passed through was in small quantity, and it contained so much earthy matter that the men did not like to drink it.

If the river water is to be drunk by the troops at Delhi, iron-tanks must be used for storing it, while the suspended matters are precipitating

A Normandy's Condensing Apparatus has been put up, but the men object to the water, as it is very flat and does not quench the thirst, it was not worked during my stay at Delhi

Meerut—The Meerut waters, which were examined and reported on by Dr Sheppard at the end of last rains, were examined this year in April and May by Dr Gage. Dr. Sheppard considered the water-supply ample and good, and Dr. Gage's Report is to the same effect. Though Dr. Gage

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examined the wells during the driest season of the year, he found from fifteen to forty feet of water in all, and the water held in solution only a very moderate amount of dissolved constituents. Dr. Gage remarks upon the presence of Nitric Acid in the water of the Royal Artillery Hospital Well, the well is in close proximity to the Hospital buildings, and in a position of possible danger

The water-supply of Meerut, though ample, and so far as Chemical analysis can inform us, good, is yet open to the same objections that must always apply to the use of wells free to all comers

Dr. Gage found the filters both in Hospital and Barracks working well. He remarks, however, that the filters do not seem to him at all sufficiently protected from the intrusion of substances floating about in the air

Bareilly—The waters of Bareilly were examined by Dr. Gage in May and June, before the commencement of the rains. The Station is supplied entirely by wells, the supply is ample, and is generally considered very good. It appears from Dr. Gage's analyses that, with but one exception, the well water contains a very moderate amount of dissolved constituents, one as little as 9.5 grains to the gallon, but the wells appear to be very objectionable, situated in respect of their close proximity to buildings. The exception I have alluded to, is in the case of the Royal Artillery Hospital Well, which here, as at Meerut, and in other stations, appears from the analysis to become contaminated owing to its proximity to the hospital building. In the case of this well, the signs of contamination are so decided, that, unless further examination should shew a difference between the soil of the locality of the hospital, and that of those parts of the station in which the other wells are dug, they must be accepted as proving it. With regard to this and the well in the compound of the Infantry Hospital, Dr. Gage writes—“Here, as at Meerut, the only wells in which Nitric Acid could be detected in any quantity were those connected with the hospital. The reason of this, I believe, to be the very close proximity of the different buildings connected with the hospital, and also the custom which the Native servants have of washing themselves around the well, which must, in time, add a considerable amount of animal matter to the soil. I would recommend that all wells, and more especially those for the supply of water to hospitals, should be sunk at a distance of about 100 yards from the nearest building, so as to remove the possibility of any matters thrown into the ground sinking into them, and also that no Native servants be allowed to go near the wells, except the beasts, and that no washing should be allowed near them. The spilled water also is not properly removed from these wells, simply falling into a small trough at the side where it becomes stagnant, and, being left unemptied, runs over and soaks into the ground about.” The state of things described by Dr. Gage is quite sufficient to account for the large amount of Nitric Acid, of total solids, and of Chloride of Sodium present in the water of the well in question

Regarding the Hospital filters, Dr. Gage writes as follows.—“These filters are on the standard plan as supplied to all Regiments. The mouths of the vessels are quite open and unprotected from dust and floating particles, and it is said that the beasts, to save himself the trouble of getting up to pour the water into the topmost vessel, or in some cases to lift it down, being placed at such a height that it is impossible to get up to it, pours the water into the lowest vessel. This would be entirely prevented by covering them in, and the height also might be made lower than at present, both by decreasing the distance between the vessels which is in some cases much more than a foot, and also by slightly altering their shape. It would be a great improvement if some means were introduced for withdrawing the waters from the bottom instead of from the top, thus always ensuring the change of the bottom water which is not the case at present; a small hole drilled in the vessel with a hard wood plug has been tried in a few cases, and has been a great improvement.”

I think it may be concluded from Dr. Gage's Report, that Bareilly is amply supplied by nature with good well water, and that by a proper choice of sites for the wells, and a proper system of conservancy in connection with them, the troops there would obtain as good and safe water as “mussucks and dholes” can afford

Agra—The Agra waters were examined by Dr. James on in December 1866, and were re-examined this year in April and May by Dr. Cameron. The waters appear to have undergone but little change during the time that elapsed between the visits of these gentlemen to the station. The Cantonments are supplied with water for all purposes from wells, which yield an ample supply of water, but its quality, as taken from various wells differs very much, in the case of only a very few

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wells can it be said to be even fairly good All the well waters of Agra contain Nitric Acid in more or less quantity, but I do not believe that this is owing to anything like sewage contamination of either the soil or of the water in the wells, for the soil itself over that District of the country contains nitrates, and there is every reason for believing that, under favorable circumstances, such as the soil and climate of Agra present, nitrification may freely occur, though all matters that could in any way be brought under the denomination of sewage may be altogether absent Still, even in Agra or in any other Nitric-producing district, if we find Nitric Acid in what may be called abnormally large quantity in any one water, we may very reasonably suspect that it is being polluted

It is unfortunate that both the analysts who have visited Agra have sent in exceedingly brief reports upon the general question of the water-supply to the troops, and I cannot learn from them whether the supply is wholly drawn from the wells which have been already analysed and reported on. It is quite possible other water sources may be in use, and may need examination

The best of the waters in the Infantry Lines is that taken from No. 75 well, it contains 30 grains to the gallon of dissolved constituents, no Ammonia, Nitric or Nitrous Acids, this well, the deepest in the Station, is 79 feet in depth. The next best water from the Cantonment Wells is that of No. 76, this well is 71 feet deep, the water is reported to contain both Nitric Acid and Ammonia The water of the wells Nos 77 and 79, each 61 feet deep, is not nearly so pure, and I think the use of these wells should be abandoned for drinking purposes in favor of wells numbered 75 and 76 The difference in the composition of these waters may depend upon the difference in the respective depths of the wells Probably, if a well, 100 feet deep, were dug in the vicinity of Well No 75, covered in, and provided with a lift pump, it would yield an abundant and good supply of water, sufficient for the drinking purposes of the whole Regiment All the wells just mentioned are apparently favorably situated in regard to their distance from buildings

Dr Cameron has not particularly reported upon the water in use in the Hospitals or Barracks, but he expresses his opinion that the method of filtration in use is faulty, and that it rather increases the proportion of dissolved constituents, probably, as he thinks, from the sand and charcoal being kept too long in use.

The Artillery, as I understand Dr Cameron's Report, rely for their supply upon the "Mottee Kooah," but he does not explicitly state this The water of the Mottee Kooah appears to be the best of the well waters of Agra, but it is a public well, much resorted to by the natives, and the water is therefore liable to accidental contamination

I cannot, from the reports, discover the source of the water-supply to the troops in the Fort I only learn that they, to a slight extent, use the water of a well situated just outside the Fort. It is a shallow well by the side of a small public tank which dries up in the hot season Such a neighbourhood is in itself fraught with danger, and the well is a public one, its water is unquestionably bad, and its use should be abandoned

Dr Jameson, when at Agra last year, examined Well No 89 in the Native Infantry Lines, and it was also examined this year by Dr. Cameron The well is 70 feet deep, it has no ridge to prevent water falling back into it, and is very largely used by the Sepoys and Camp-followers. The water contains a great deal of saline matter, 101 grains to the gallon, including a large amount of nitrates, the water is no doubt contaminated by the percolations from the Native Lines, but the Sepoys like it, and they say it assists their digestion

The water from the River Jumna was examined by Dr Cameron It is considered by the natives the best water that can be had in the Station, and such, from analysis, it appears to be, but the river is a long way from Cantonments, and could not, unless at great expense be used to supply them, nor is it needed in my opinion, for properly arranged wells, would yield a good supply An artesian boring might greatly improve the water-supply of Agra

Morar, Gwalior—This Station was visited by Dr Cameron in June and July of this year. The Station is supplied by wells of no great depth, from 30 to 40 feet, and, of those reported on, one-half run dry in the hot weather, and the water in the remainder is very low Dr Cameron does not state if any scarcity results from the drying up of so many wells, or whether there are other sources of supply at hand to which the troops can resort Neither does Dr Cameron report generally upon the supply for the Cantonment, either as regards its quantity

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or quality, but he states that the people entertain a bad opinion of the water, and that many wells in the city of Gwalior have had to be abandoned in consequence of their becoming salt

The wells in Cantonments appear to be badly situated as regards their proximity to buildings The water in every well contains Ammonia, Nitrous and Nitric Acids, and a rather large amount of oxidisable organic matter Dr Cameron also states that the well waters contain sulphuretted hydrogen, some of them in considerable amount, but this, and other points connected with the water-supply, must be elucidated by an examination carefully conducted during next hot season

The water of the tanks in the Fort and of the Morar River were not examined. At the request of the Brigadier Commanding at the Station, Dr Cameron visited and examined the waters of a village in the neighbourhood of the Cantonments, and I copy his Report, as it presents a fair picture of the conservancy of a native village, and indicates the danger in which almost every station is exposed, however perfect its internal sanitation may be It is to be feared we shall never be without Cholera amongst our troops till an improved civilization, spreading through the whole country, supports our efforts, by expelling the disease from its homes in such villages as that described by Dr Cameron

"The village in question is inhabited by natives engaged in the manufacture of bricks, in the burning of which they use the refuse litter of the Cantonment of Morar Large quantities of the refuse litter or dung are stored up in heaps in close proximity to the wells The wells are all kutcha, and without platforms or other means of preventing substances getting washed into them from the dung heaps They are all situated in a confined space measuring about 900 yards square The soil through which they are sunk is of the same nature as that of the Cantonment A slight epidemic of Cholera prevailed in the village in the latter part of June 1867, 35 persons in all were affected, of whom 12 died, unfortunately the well, from which most of those affected procured the water, had been filled up by order of Dr Mornice before my arrival

"The analyses were performed subsequent to July 8th, and before the rains had properly set in, so that the water in the wells could not be much diluted Amongst those using the water of No 6 there was one fatal case, No 7 is the Chamars' well, none of whom were seized with the disease The well which was filled up was further removed from the dung heaps than any of the others It was situated in the middle of a few native huts, being distant about 5 yards from them, and on a lower level, so as to be exposed to having filth and human excretions washed into it

No	Total hardness, Clarke's scale	Permanent hardness, Clarke's scale	Removable hardness, Clarke's scale	Grains of oxygen necessary to oxidise readily oxidisable matter in 1,000 grains	Total solids per gallon	Volatile matter per gallon	Mineral matters per gallon	Chloride of Sodium per gallon	Carbonate of Soda per gallon	Sulphate of Soda per gallon	Nitric Acid qualitative reaction with Brucine
1	4 5°	2 4°	1 4°	00091	51 45	5 88	45 57	8 47			Slight
2	4 15°	1 86°	1 73°	00181	42 91	4 2	38 71	18 9			Decided
3	6 2°	2 18°	3 3°	001705	45 15	4 78	40 39	4 27	11 45	5 78	Ditto
4	5 7°	85°	4 2°	00277	49	3 04	45 36	10 5			Ditto
5	5 7°	1 68°	3 35°	001725	33 6	3 5	30 1	6 16			Ditto
6	6 45°	4 16°	1 63°	00091	39 62	2 8	36 82	4 48			Ditto
7	4 5°	2 76°	83°	00164	41 3	8 4	32 9	7 14			Ditto

"The amounts of Chloride of Sodium are much higher than in the Cantonment Wells The village in question is situated on the opposite side of the Morar River at a distance of about 1,000 yards from the 22nd Punjab Native Infantry Lines The average amount of Chloride of Sodium in two wells in these Lines was 2 94 grains per gallon There can be no doubt that the large amounts of chlorides and organic matter in the wells of the village are due to the near proximity of the dung heaps, and that their impurities have much to do with the access and propagation of Cholera amongst the inhabitants"

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Jhansie—Dr Griffith analyzed the Jhansie waters in June last. The station is supplied entirely by wells which are of various depths, from 30 to 40 feet, one only (No 11) is as much as 59 feet in depth. The wells are stated to be dug in alluvium mixed with granitic debris. The supply of water is apt to fail in the hot season, and is then supplemented by digging wells in the beds of the dry nullahs which traverse the station. People at the station unite in giving the water a good character for purity and wholesomeness, and Dr Griffith, looking to the results of his analysis, expresses a similar opinion. He says—"The waters at Jhansie are of very good quality. The supply is apt to become very little in the hot season, this is obviated by digging temporary wells in the channels of the dry streams which traverse the Cantonments. By this means, abundance of water for the horses, bullocks, and sattris is obtained, and what little water is afforded by the regular wells is reserved for drinking and cooking. Most of the wells are kutcha, and it would be an improvement if they were laid with bricks and mortar. The practice of the Natives of washing their bodies on the platforms of the wells is common here as at most other stations, it is very reprehensible and disgusting, for, in such of the wells as have no ridge, some of the water charged with organic matter from their bodies cannot be prevented from returning to the well. Cholera and other diseases may be introduced into, and propagated in, Cantonments in this manner."

The water of one only of the wells appears from its analysis to be decidedly bad, this is Well No 10, in front of the Native Cavalry Lines, the water contains a very much larger amount of dissolved constituents and of oxidisable organic matter than the other wells. There is no ridge round the mouth of the well to prevent the water running back, and as the well is largely used by the Natives, it may be, and probably is, defiled by the washings of their bodies. Further, Dr. Griffith states the existence of two holes, 6 feet from the well, one of which was used to receive the mud lately cleared out from the well, and the other receives the filth of a neighbouring bungalow, such conservancy is hardly credible.

It is observable, as illustrating the effect of the manners and customs of the people upon the wells (though, indeed, this is even more strikingly shewn by the state of the water of bazaar wells) that Wells Nos 9, 10 and 12, which are largely used by the Native Troops, are more impure than those used by the Europeans, the probable source of contamination in the case of No 10 has already been indicated. No 9 is overhung by a large Peepul tree, and numerous saucer-shaped depressions containing dirty water surround the well which is close to the Native Lines. No 12 also has numerous depressions around it, and Dr Griffith notices the existence of a large Native Privy, 50 yards from the well, but on a higher level than it. The water of Well No 11 which is also used by Native Troops, but which approaches in purity to that in the wells in the European Lines, is a long way, 800 yards, from any Native hut, and probably on that account is not much frequented by the Native Cavalry, whose Lines most nearly approach it.

The best of the wells reported on are Nos 6 and 8, which belong to the European Infantry. The wells are sufficiently distant from any buildings, and in their neighbourhood there are no accumulations of filth, nor are there any saucer-shaped depressions which could retain dirty water, but the wells are not provided with ridges to prevent spilled water falling back into them.

All the well waters reported on contain a notable amount of nitrates, but as Dr. Griffith found nitrates in a specimen of soil taken from a locality free from any liability to artificial pollution, the nitrates in the well-water need not be ascribed to the oxidation of sewage matters.

Saugor—The Saugor waters were examined by Dr Griffith in May 1867. The Town and Fort of Saugor are situated on a lake which receives their drainage. This lake is about 4 miles in circumference, its sides are of masonry, and are overhung with trees. The water of the lake is used by the inhabitants of the town, and by others living upon its banks for all purposes, and the water has, in consequence, lost its natural purity, and has become unfit for human consumption, yet the people drink it, and Dr Griffith reports that some people like the water, think it wholesome, and believe that it has the power of assisting digestion. The water is described as turbid, of a yellowish color, having a sweetish taste, but a smell like that of decomposing vegetable matter. Analysis shews that it contains sulphuretted hydrogen, and a great deal of readily oxidisable organic matter, but it does not appear to contain a large amount of dissolved constituents.

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It would not, however, be right to form a decided opinion as to this or the other Saugor water from the results of the reported analysis, for Dr Griffith commenced operations at this station and met with difficulties there, especially in the use of the balance which render his results to some extent unreliable.

The European Infantry are supplied from a well about 100 yards from the Barracks; the well is uncovered, and has no ridge to prevent the return into it of the spilled water. There are no deposits of refuse or filth in its neighbourhood, but Dr Griffith reports a tank at the edge of the platform in which water remains stagnant—"The well is 69 feet deep, and passes down through a dark colored soil made up of disintegrated basalt and trap", it contained 12 feet of water at the time of Dr Griffith's visit. The water is very hard, and appears to contain a large amount of dissolved constituents. I suspect it is a very indifferent water.

The well which supplies the Artillery (No 3) is 47 feet deep, and contained 3 feet of water at the time of Dr. Griffith's visit; the well is protected by a ridge, it has no platform, but a dry water-course carries away the spilled water. The water of this well appears to be better than that of the one just described. Wells Nos 8 and 2 aid in supplying the European Troops, their water resembles that of No 3; No 8 supplies the Artillery Hospital. The European Infantry Hospital is supplied by Well No 15, which is situated close to the Soldiers' gardens, the water is better than that of the wells already mentioned, but the supply from the well is very limited. The Native Hospital is supplied from a well close to the Cavalry Lines, the water resembles that of No 15.

There is a well in the Fort close to the lake, its water is reckoned bad, and is not used by the European Troops quartered in the Fort, it is very probably fed by percolation from the lake.

Jubbulpoor.—Dr Griffith analysed the water of Jubbulpoor in June, before the setting in of the rains. The station appears to be well supplied with water of very fair quality by numerous wells, which are, for the most part dug at the top of the various little hills on which the Barracks are situated. The water of the Nurbudda River is also used to a considerable extent by both Europeans and Natives, its water is very good, but, like all river water, needs filtration.

The wells are placed at a safe distance from buildings, and their conservancy is apparently good, except that they all need an encircling wall, and are, of course, exposed to danger from the resort to them of Native servants. Their waters appear to be good, but further examination of them, as of the Saugor waters, is needed to allow of their quality being fairly judged, the water of the station is generally considered wholesome.

There is, however, one well in the station, and that not an unimportant one, which is unquestionably very bad indeed, this is the well in the Native Infantry Lines from which the Sepoys take their water, which, of course, they drink unfiltered. There are huts very close to the well, no doubt, more or less directly receives the washings of the bodies of the Sepoys, and a portion of other of their excretions, besides that of the skin, the water is reported to contain 93 grains to the gallon of solids, including a large quantity of nitrates. The Sepoys, though they consider the water bad, continue to use it, but a Sepoy will drink anything that comes out of a comrade's lotah, and their alleged precautions extend only, I believe, to the ceremonial, which is by no means co-extensive with the actual purity of the water imbibed.

Dinapoor—The Dinapoor waters were first examined by Dr Durant in September of 1866, they were re-examined by Dr Jameson in May and June 1867, and again by Dr. Jameson last month (September). Dr Durant considered the water-supply of the station very bad, and Dr Jameson's examination entirely supports that opinion. Dr Jameson agrees with Dr. Durant in considering the Hospital Well, and the well attached to the cells, the best wells in Cantonments, and he ascribes their comparative purity to the fact of their being very near the river bank, and in the old bed of the river. When Dr Jameson examined the water of the well in the Garrison cells in May last, he found it contained considerably more dissolved constituents than when it was examined by Dr. Durant, but he thought this due to the well having been cleaned out just before his visit. When re-examined last month, the water had almost precisely the same composition as

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when it was analysed by Dr Durant This well is too close to the cells, and it has no platform, while the only means of escape for the waste water is through a groove in the ground leading to a large drain outside the cell enclosure

The Hospital well is situated between the hospital and the river, 22 yards from the former, and about 30 yards from the latter, on either side of the well, about 40 yards distant, are large Latrines and Urinals, and I think that, even at this distance, they may imperil the well water, especially as from Dr Jameson's Reports, it appears that the water circulates very freely through the sub-soil. The well is partly covered by a wooden platform, on which the bheasties stand when drawing water, and Dr Jameson remarks, as did Dr Durant, upon the possibility of the well becoming infected by the washings from the bheasties' feet when they come barefooted to the well after traversing the Hospital wards. The well yields an abundant supply, and as appears from the analysis of the water, its constitution is very constant, and fair for well water

The well of No 1, Permanent Barracks, is strongly commented on by both Dr Durant and Dr Jameson. It is 5 yards from the Women's bath, 26 yards from Barracks, 30 yards from two Cook-houses, the spilled water lodges in the drain intended to carry it off, and 26 yards off is a drain in which water lodges, and into which the dirty water from the Barracks is thrown. Dr Jameson writes — "This water is very bad, at the time of my visit the surface of the water was nearly covered with leaves, dust, &c, while a large number of frogs were swimming about in it. The ditch in front of the barracks was full of water owing to the river flowing back through the drains. Probably this ditch is one source of contamination, probably, too, there is some leakage from the Plunge Bath. The well is also the natural drainage of part of the barracks, and of a couple of Cook-houses. In front of the Cook-houses there is usually a good deal of dirty water lying about." Analysis shows that the water is very impure, the Medical Officer in charge of the Regiment informed Dr Jameson that the water of this well caused Diarrhoea and Dyspepsia to those using it.

Well between Nos 13 and 14 Barracks — Dr Jameson writes, speaking of the water of this well — "It is only meant to be used for washing, &c, but the barracks on each side are supplied with drinking-water from this source." The water of the well is very bad indeed, and Dr Jameson thinks this in part due to the ground about it being turned up for Soldiers' gardens, and in part, to the fact, that the greater part of the waste water finds its way back into the well, he thinks the well should be shut up.

Well No 3, Temporary Barracks — This well is 10 yards from a block of barracks, and 24 yards from a Wash-house at the end of which is a Latrine. The water of this well is said to cause Diarrhoea and Dysentery, it is evidently very impure.

The Artillery Well supplies the Artillerymen and their horses. Dr Jameson says — "In the rains this well stands in the midst of mud and water, caused by the horses being led to the well to drink. There is a small drain around the well where the water lodges. It is very dirty, too, containing two or three inches of mud. Formerly the horses were picketted 16 yards from the well, but they have now been removed to stables 40 yards distant from it." Dr Jameson thinks the water should be used for horses only, 'for,' as he says, "as long as the horses are led up to the well to be watered, the water cannot be expected to be good. Manure is carried on the horse's feet, more or less of it is deposited near the well, and most of this will find access to the well when rain falls, owing to the very porous nature of the soil." In the dry weather, this water contained 39 grains to the gallon of dissolved constituents, including 5.6 grains of common salt, but when examined by Dr Durant, at the end of the rains of 1866, it contained 66 grains of solid matter to the gallon, including 11 grains of common salt, and at the end of the last rains the water held in solution 50 grains to the gallon of solids, including 10 grains of common salt, evidently, the rain-water washes a great deal of impurity into it. Most unquestionably this well should not be used to supply drinking-water to the troops.

Dr Jameson, during his last visit to the station, analysed the water of one of the wells in the Native Infantry Lines, the well is reckoned the best of the command of the Native Troops, and from its position, immediately upon the edge of the River Soane, might be expected to contain good water. There is a masonry platform round the well, but no drain to carry away the waste water which collects

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round the edge of the platform, and sinks into the soil beneath it. The water contained, as reported by Dr Jameson, 68.5 grains to the gallon of dissolved constituents. Regarding this well Dr Jameson writes — "This water is stated to be the best in the 11th Native Infantry Lines. The wells in the Hospital compound, and the two wells in the Lines between the one examined and the hospital, are stated by the Sepoys to be unfit for use. That there should be such an amount of solids seems incomprehensible, seeing that the well is sunk as near the river bank as it can be. When I visited the well, I found a number of Sepoys washing themselves and their 'lotahs' at the well, all or a greater part of this water passes again into the well through a small hole underneath the platform. A masonry ditch, 4 or 5 feet long, could carry all the spilled water into the river, and prevent this fruitful source of contamination. Cholera has occurred in these Lines three times during the last three months. From its proximity to the river, I cannot help thinking this well ought to yield good water, a ditch ought to be made round the platform. I fancy the well stands in great need of cleaning out."

Bad as is the supply of water to the European Troops at Dinapoor, that for the Native Troops is evidently far worse. The well just described is between the west angle of the Line and the river, and no doubt receives a portion of the drainage from the Lines. I would suggest a well being dug on the banks of the river, about 70 yards to the west of the old well, in the corner near the west boundary line of the Cantonment. The old well should be cleaned out and provided with a masonry drain as recommended by Dr Jameson.

Dr Jameson examined the river water both in May and October. In May, it contained to the gallon 11.9 grains of dissolved constituents, in October 14.3 grains, the increase being chiefly in the amount of soluble salts. The river water is infinitely better than that of any of the station wells, and I beg to urge most strongly, Dr Jameson's recommendation to supply the station from that source. His report upon the water-supply of the station is as follows — "With the exception of the well in the General Hospital, and that in the Garrison cells, the water used by the troops is exceedingly bad. The constitution of the latter, too, varies considerably. In the hot season, there were ten grains of solids in excess of the present amount, and this increase was due mostly to organic matter. That there should be great variation in the constituents of the water might be predicated. The surface of the soil is constantly falling in, owing to the water underneath clearing for itself channels about a foot and a half below the surface. When the river was falling, streams of water, as thick as a man's arm, were pouring out of the bank, a foot or two from the surface. If, therefore, the ground be turned up, or manure, &c, be deposited within the drainage area of a well, a large amount of foreign matter will gain access. It seems to me, therefore, that having wells at all in Dinapoor, is a mistake. It would not be a difficult matter to supply the Cantonments with excellent water from the river. If pipes were laid to a point 1 mile or so from the Church, and the river end of the pipe elevated a few feet, there would be plenty of fall. The water might be filtered, too, at the river, and be supplied to the barracks ready for use. I do not believe sinking new wells, or altering the old ones, will be satisfactory."

Hazareebaugh — The waters of this station were first examined by Dr Durant in November last, and since then they have been twice examined by Dr Thomson, first in the hot dry season of this year, and subsequently during the rains. The troops are entirely supplied with water for all purposes, by wells which are of pretty uniform depth, about 37 feet, the wells are said to pass through a thin stratum of humus, and then through sand, clay, and granitic debris. The water from many of the wells is exceedingly good of the kind, thus the water of the hospital well contained in July last, only 8.98 grains to the gallon of dissolved constituents, including but a small amount of volatile matters, only 67 grains of common salt, no Nitric or Nitrous Acids, or Ammonia, during the rains the water became slightly more charged with dissolved constituents, and was found to contain a little Nitric Acid. I may here notice a peculiarity in the well waters of Hazareebaugh, namely, that, while they contain (with the exception of those which are pretty plainly contaminated artificially), no nitrates in the hot weather, these salts are present in them during and after the rains. I conclude, that the rains wash the nitrates from the soil into the wells. The Hospital Well contains rather a large amount of oxidisable organic matter, but this may be due to leaves and droppings of birds falling into the water from the tree which overhangs the well, this well, too, is used by the Natives, and may thence become slightly contaminated. I would most strongly urge the sp-

The neighbourhood is comparatively bare of trees or underwood. No jungle of any consequence exists within 2 or 3 miles of Cantonments. The trees are either solitary or in small groups, and afford little shelter to the soil. Rice and other cereals are grown in Spring and Autumn. Tea grows very well. But the soil is in general of no great fertility, stunted grass and scraggy shrubs grow naturally.

The sites of many of the wells have been injudiciously chosen, or rendered sanitariously objectionable after their construction. The well now being built in front of the Officers' barrack is 15 paces from a public privy. Others are in situations equally bad, some at the doors of Washing-houses, or at the root of a large tree, or in the centre of a group of trees, or in a garden. One private well is in close relation to a tank of green putrid water.

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The bazaar wells are sunk in the same soil as those in Cantonments, on a somewhat higher level. They are generally situated at the side of a public thoroughfare, close to the houses or shops of the Natives. The water of particular wells is frequently used by only one sect of the community. The water of these bazaar wells is often used also on the spot, for the purposes of ablution, the bather sitting on the edge of the brick-work, so that much of the rejected water again finds ingress to the well.

Leather buckets are used by the bheasties in drawing the water, by means of which the skin bags, in which the water is dispensed, are filled, hence, probably, another source of contamination.

Station water is, as a rule, clear, colorless, and without taste or odour, one gallon of it containing from 8 to 20 grains of solid matters, somewhat less than half of which is soluble in water.

The water before being used by the troops for drinking is invariably passed through the Barrack filters. These are faulty. They consist of two or three ghurrahs, one above the other. Into the upper ones are thrown sand and charcoal. The lower, receive the water which has passed. The bottom of the upper vessels is perforated by a considerable hole, in which is placed a bit of brick, over which the water descends.

The effect of these filters is to deprive the water of its suspended matters, and to increase its deoxidising properties. They possibly cause no change in the quantity of mineral matter.

Fort William—The Fort is now entirely supplied with water for all purposes from the two tanks at the foot of the glacis. The tanks are large, and well kept and guarded. I examined the water of both in April last, and of the new tank again on the 17th September. Between the tanks is a masonry cistern which on the opening of sluice gates can be connected with both, or either tank, but before entering the cistern, the water has to pass through a considerable thickness of sand and broken brick. On the occasion when I examined the water in September, the water from the old tank was shut off, and had been so for some days. From the cistern the water is raised by means of a pump worked by a steam-engine to a cistern on the ramparts, and thence it is distributed to stand pipes placed about the Fort. In order to raise the water to the level of the upper-storeys of the barracks, it is during a part of the day forced up a lofty syphon pipe, the level of which is above the level of the barracks. The tanks are filled partly by direct rain-fall, partly by percolation through the soil, but chiefly I suspect, by the system of surface drains which, spreading over the maidan, terminate in main drains leading into the tanks. These drains, at their entrance into the tanks, are provided with sluice gates, by means of which the entrance of the water can be prevented. It is evident that, if the water of the first rain-fall at the commencement of the rains was let into the tanks, it would carry into them, from the surface of the maidan, and from the drains, the accumulated dirt of the preceding eight months, and to obviate this, the system of drains is so arranged, that the water is at first allowed to flow into the river, and subsequently, when it is concluded that the plain has been scoured, the water is permitted to fill the tanks. This arrangement is very good so far as it goes, but from an examination of the water taken from the drain towards the end of the rains, I find that an immense amount of sedimentary matter is carried into the tanks in addition to a considerable amount of dissolved organic matter, and I would here remark that, if this is so in the case of a well-kept and comparatively clean maidan, how much dirt must be swept by the rains into some tanks. So far as I know, the arrangement in the Fort William tanks for scouring the maidan is unique.

I suppose that, as a very large supply of water is needed for the Fort, it is necessary to reinforce the tanks by surface drainage, otherwise, it would be far better to adopt the plan in force at the General Hospital, of allowing the tank to be supplied only by percolation and direct rain-fall. Might not the water in one of the tanks on the glacis be improved by making the other a settling tank, in which the water from the maidan drains should be allowed to stand in order to settle before being transferred to it?

At my suggestion, a small well is being dug in the space between the two tanks, but as it had been only just commenced when the rains began, no satisfactory experiments could be made in

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comparing its water with that of the adjacent tanks. I am of opinion that, if a well in this situation is filled with sufficient rapidity from the neighbouring tanks, the intervening earth would form a natural filter, which would be very effective in freeing the water from suspended matter, and probably from dissolved organic matter also. I shall compare the water of this well with that of the tanks during next dry and rainy seasons.

The dissolved inorganic matter in the tanks is small in amount, and the water in the new tank is evidently improving. In September 1866, a gallon of the water held in solution 13.7 grains inorganic matter, this September, I found that quantity was reduced to 7.7 grains. The water from the new tank, this September, I found that quantity was reduced to 7.7 grains. The water from the newly erected stand pipes in April last deposited a considerable sediment, chiefly of iron rust, but in September the water was clear. The water from the stand pipes now resembles that from the in September the water was clear. The water from the stand pipes now resembles that from the new tank in respect of its dissolved constituents, only containing a little less organic matter. The water is re-filtered in the barracks through the old style of filter. Great attention was paid to the filters during the time the 3rd Brigade of the Rifles garrisoned the Fort, and the filtered water was always, when I examined it, physically good, but the filters added slightly to the amount of oxidisable organic matter in the water. These filters should be disused, and either the Danchells or some similar filter should be introduced, or the whole of the water should be passed through animal charcoal, before being distributed in the barracks. Unfortunately, as the water from the stand pipes is used by Natives troops, it cannot, for general distribution in the Fort, be filtered through the animal charcoal.

General Hospital—Both the General Hospital and the adjoining Military Hospital are supplied with water for all purposes from a tank situated under the east wall of the Hospital compound. The water of this tank very closely resembles that of the new tank on the glacis, and, excepting that it contains a large quantity of oxidisable organic matter, is very good. The tank was formerly in part filled by surface drains collecting the water of the compound, but these were stopped two years since, and the tank is now said to be filled by direct rain-fall and by percolation only, but the surface of the compound slopes in some places towards the tank, and I suspect water drains directly into it. In connection with this subject, I think a very useful experiment might be tried on some conveniently situated tank to determine the quantity of water entering it during the rains by direct rain-fall, and by percolation respectively, the edges of the tank being raised to prevent the entrance of any surface drainage. I suspect the tank would fill, and would fill with much clearer and purer water than if replenished in the usual way, but to make the experiment a thorough one as regards water, it should be made upon a clean tank, and not only the quantity but the quality of the water, it should be made upon a clean tank, and not upon one which, like that in the General Hospital compound, contains the accumulated sediment of many years. This tank is not properly guarded, for I myself saw an individual washing at the edge of it, and doing so apparently as a customary thing. I would strongly recommend that the tank be railed round, and that its edges be raised, thus affording a reverse slope which would entirely prevent the entrance of the surface drainage.

Near the north-east corner of the tank, about 10 or 15 yards from its edge, is the Latrine which is used by the sepoy of the Hospital Guard. It is upon the dry-earth system, and, when I visited it, was in an unexceptionable state of cleanliness, in fact, there was nothing in the atmosphere of the place to reveal its use. Immediately outside the entrance is a masonry drain, in which the men perform their ablutions, and which leads the waste water away outside the wall of the compound into a large drain. So long as the proper conservancy of this Privy is preserved, it is hardly possible that it could become a source of danger to the tank, but in old times and under the old system, the Privy must almost necessarily have added pollution to the tank water. The worst feature in connection with the Hospital tank is the large drain immediately outside the wall of the compound, up to which the tank reaches. The drain in question is nothing but a deep wide ditch, the chief use of which is to carry off a part of the rain-fall from the maidan into Tolly's Nullah, but it serves a subsidiary purpose in acting as Privy and general receptacle to the bazaar to the east of the Hospital compound. I have no doubt that the tank drains any stagnant water from the ditch, and becomes contaminated by it. I feel sure the ditch would not have so long been allowed, were it not that the compound wall hides it from sight.

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By the tank ghat stands the filtering tower which will be presently described, and here the drinking-water is filtered prior to its being carried to the hospital, the water for cooking and for other purposes is taken from the tank in the usual way by the bheasties. In the hospital, the water is drunk in the state in which it is taken from the tower filter, the bheasties filling the earthen-jars which stand in the hospital verandah, and also the water bottles which stand between every third or fourth bed in the hospital. These bottles are, however, more commonly filled by the ward coolies, who make use of a tin-pot for the purpose, dipping it into the water-jar, a plan which has only the sanction of custom in its favor.

Barrackpoor—At Barrackpoor, the troops both European and Native, take their drinking-water from the Havildar's tank, a fine large tank on the parade ground. The water of this tank, in its greatest state of concentration at the end of the hot dry season, contained only six grains to the gallon of dissolved constituents, of which 9 of a grain was volatile matter. Towards the end of last rains, after a heavy rain fall, the water contained but 4.55 grains to the gallon of solids, of which 1.05 was volatile matter, but on both occasions it contained a large proportion of oxidisable organic matter. In May, the water had a slightly earthy taste, and was of greenish hue. Yet, though the water, judging from its analysis, might be pronounced good, I believe in its present state the tank is not an altogether safe source of supply, for it is unguarded, and, though a railing extends partly round, it affords a very insufficient protection. When I was there, I saw two extremely dirty-looking individuals step into the tank, and take water with which they washed themselves on its edge. Further, the tank is in part supplied by a large drain, the gathering ground of which extends into the Infantry Lines. About 40 yards to the east of the tank is a line of stables, standing on ground a little higher than the tank, the stables probably do no harm in the dry weather, but the first heavy fall of rain must sweep a considerable quantity of refuse from them, as well as much other dirt, from the gathering ground of the drain, I have mentioned, into the tank. The tank should be enclosed and guarded, and no washing should be allowed near its edge, and I think the edge of the tank should be raised, so as to give it an outward slope. If it is necessary that the tank should be supplied from the surface drain, some arrangement should be made for directing the first washings of the ground into another course. I think it probable that a good filter, would remove the greater part, if not all, of the organic matter which results from the decomposition of the vegetable debris present in the tank water.

The supply from the Havildar's tank is not completely sufficient for the troops, and it was stated to me that, despite the apparent chemical purity of the water in May, those using it at the time thought it bad, and, moreover, the supply was scanty. It is to be remembered that this tank is used by a large number of troops, as well as by camp-followers, and it is not therefore to be wondered at, that the water runs low in the hot dry season, and, doing so, acquires an earthy taste and greenish color, and it would appear to be very necessary that the water supply for the troops should be augmented, either by the use of wells, or by cleansing and enclosing one of the other numerous tanks in Cantonments. But might not the Havildars' tank be devoted to the use of the Native troops, while the water for the new European Infantry barracks might be taken from the main of the Calcutta Water-works which runs close to them? The water could be pumped into a sufficiently lofty cistern to allow of its being supplied at high pressure to the barracks. For general purposes, the water might be used as taken from the main, while the drinking-water should be filtered in the several wards.

Underneath the north wall of the European Hospital, and close to the hospital buildings is a tank known as the hospital tank. The ground on which the hospital buildings stand forms a part of the gathering ground of the tank, while other buildings are also close upon it. Further, the tank is partly filled by the help of a large drain which enters its north-east corner, and has, as its gathering ground, the Native Bazaar. Thus situated, it is not to be wondered at that the tank is reckoned bad, and becomes, as it concentrates during the hot weather, quite undrinkable. It must be very liable to pollution. I was assured by the Medical Officers that the water of this tank is not used for drinking purposes, and the hospital steward, whom I saw when I visited the tank, confirmed this report, but he allowed that no guard was placed upon the bheasties, and that it was possible they might fill the hospital filters from this tank. The Sirdar bheastee, who was sent with me

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to point out the Havildars' tank, informed me that the bheasties did supply the drinking-water for the hospital from the hospital tanks, and if his statement is correct, I can quite understand the presence in the filters of the horrible stuff which was taken from them, and sent to me for analysis—stuff such that I am sure no one but a patient in the delirium of fever could be persuaded to drink. There must always be danger in the use, in a Hospital or a Barrack, of two waters,—one of which is unfit for drinking, and especially when, as is the case at Barrackpoor, the one tank is under the hospital walls, while the other is at a very considerable distance. Bheasties are just the kind of people to contrive to save themselves all the trouble they possibly can, and as, if found carrying the inferior water into the hospital, they would have the excuse that it was intended for the bath-rooms, they would very securely use it for the filters also.

Dum-Dum—The European Troops at Dum Dum are supplied with drinking-water from the Diglah tank, which is at a short distance from the barrack square. The water of the Diglah tank is entirely-resembles that of the Calcutta tanks, but contains more dissolved constituents. The tank is entirely unenclosed and unguarded. During my visit I noticed several Natives washing upon its bank. The tank is filled by direct rain-fall, by percolation, and by surface drains. A very large drain opens into its north-east angle, and this drain, I was told, reaches away to a great distance, passing into the bazaar. I think that means are urgently needed to improve the conservancy of this tank, and I would suggest the following—That the open space around the tank (it is not very extensive) should be enclosed, and strictly preserved as the only gathering ground for the tank, all drains proceeding beyond it should be stopped, the ghat should be guarded, and no one should be allowed to wash in its neighbourhood. The water should be passed through an efficient filter before being used for drinking purposes.

Not far from the Diglah tank is the School tank, it is not now used by the troops, but is largely used by the inhabitants, and is considered very good water. When I visited the tank, I noticed many people taking water from it. In the centre of each each of three sides of the tank, and close to its edge, are buildings which I took to be bells-of-arms from their symmetrical disposition, but which on enquiry I learned were privies. I give an analysis of the water of the tank, for it confirms what might be expected as to the impurity of the water, and serves to shew the result of contamination in effecting the amount of solids in a water. The School tank is similarly situated as regards soil to the Diglah tank, and its water would no doubt resemble that of the Diglah tank, were it not that it is more decidedly open to contamination.

The European Hospital is supplied by a well, known as the hospital well, it is situated on the edge of the maidan in front of the hospital, a road intervening. The water is carried to the hospital by bheasties. The well is used, not only used by the European Hospital, but for the Native Hospital also, and when I visited it, Natives, apparently sepoys, were drawing water from it. The well is situated in a small enclosure, and I should say all the spilled water found its way back into it. When I was there, it was so surrounded by bogs and ditch that it would have been necessary to bare one's legs to the knee to reach it. At a short distance, about 20 yards from the well, is a small and very dirty tank which is used for all purposes, including bathing cattle and washing clothes, the water in this tank becomes very small in quantity and very foul in the hot weather, and I should think that when the water in the well falls low, that from the tank would be very apt to drain into it.

I would recommend that the present wall, which encloses the well, be removed, that the well be provided with a properly constructed ridge and platform, that the ground around it be raised, and that the tank in the neighbourhood be filled up with broken brick. Another well should be provided for the Native Hospital, and only the bheasties of the European Hospital should be allowed access to the present well, of course a still better plan would be to provide the well with a pump.

Lucknow—Dr. Orton was appointed to examine the waters of the Cantonments of Lucknow, Seetapoor, and Fyzabad, during the last hot season, but his duties as Assistant Sanitary Officer detained him in Lucknow, and he chiefly devoted himself, under the instructions of the Commissioner, to the examination of the waters of the city wells. Dr. Orton did, indeed, examine some of the wells in Cantonments, but, under some misapprehension, only the condemned wells which are not in use by the troops. His report, therefore, throws no further light upon the water-supply of the

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Cantonments than that obtained from Dr Bonavia's Report , but, I think, the Report is well worthy of consideration, for Dr Orton has been at great pains to make it complete as regards the water-supply to the city, and incidentally it represents very fairly the dangers to which the water-sources of the country are very generally exposed

Dr. Orton examined the water of the River Goomtee, taking it at a point a quarter of a mile above the city. The water is far better than that of any of the Station wells which have as yet been reported on, and it would be a great boon to the city if it were supplied from the river by a pipe, which might also supply the Muchi Bhawun Fort and the new Fort. The water of the Muchi Bhawun is evidently very bad indeed, and it is most necessary that a wholesome supply should be provided for the use of its inmates.

Allahabad—The waters of this station were examined by Dr Milne in November and December 1866, and again during April and May of this year

The troops are entirely supplied with water for all purposes from wells which yield an ample supply of water, the water from all the wells is of very uniform quality, and for well-water fairly good. The wells appear to be advantageously placed as regards distance from buildings, but an objectionable feature in connection with some of them is the existence of a trough for watering cattle placed by the side of the well

Dr Milne analysed the water from the Ganges and Jumna Rivers, the former is evidently far the purer of the two

Since writing the above, I have received the Report of Dr Compigné, who was engaged in analysing the Allahabad waters during a part of September and October last. Dr Compigné examined two of the public wells of the station, and also a well in the new Cantonments, the waters of these wells closely resemble those of the wells analysed by Dr Milne, and re-examined by Dr Compigné.

Dr Compigné mentions in his Report, that the analysis of the waters of the old Cantonments is, perhaps, of little consequence as they will shortly be deserted, the troops moving into the new Cantonments. The water of the well in the new Cantonments might be pronounced good, if it were not for its degree of hardness which is greater than that of a thoroughly good water, but the hardness may, perhaps, be increased, owing to the presence in the neighbourhood of the well of much lime in use for the buildings in course of erection.

The well, however, if I rightly understand its position, is too near to the barracks, and another well should be provided to supply drinking-water to the troops. I think a position for the drinking-water well should be chosen between the north end of the new barracks and the river, but not in the line of drainage, and the well should be at least 50 yards distant from any building. I believe that a properly constructed and guarded well in that position would, on the whole, yield a supply preferable to that which could be derived from the river, for the river-water, though comparatively very pure as regards its dissolved constituents, becomes loaded with finely divided siliceous matter at the commencement of the rains, and this could only be separated by allowing the water to rest in tanks for subsidence during several days. Filtering apparatus might be put up near the well, and from it the filtered water should be supplied, on the constant system, to the barracks.

Cawnpore—The Cawnpore waters were examined by Dr. Jameson in September and October 1866, and by Dr. Milne in April, and again in May 1867.

The troops are entirely supplied from wells. The wells have a pretty equal depth from 60 to 70 feet, and they yield an ample supply of water, but there appears to be considerable difference of opinion as to its quality. The more general opinion appears to be, that the quality of water is not good.

Well No 15 appears to be one of the best ; there is no indication from analysis of its suffering any sewage pollution, but it has a high degree of permanent hardness

Well No 19 contains, according to Dr Milne's analysis, Nitrates, and I suspect, from the very large amount of volatile matters, a larger quantity of these salts than the analysis represents, it also contains a large amount of Chlorides

Well No 7 contains a large amount of Nitrates and Chlorides Well No 9 is stated not to contain Nitrates, but I cannot help thinking, from the large amount of volatile matters, that the

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Nitrates may have been overlooked. I regret Dr Milne did not examine the soil in some place not accessible to pollution, in order to determine whether these salts naturally exist in it, and to what extent.

I cannot but think the wells must be liable to pollution, for they are almost all badly placed as regards proximity to buildings, thus No 13 is within 15 yards of a Cook-house, and 20 yards from a Lavatory. No 19, 12 yards from a Latrine, and about the same distance from a Store-house No 3 has Latrines on either side at a distance of 20 yards No 9 has Lavatories at 9 yards' distance No 7 is distant 12 paces from a Lavatory Further, the wells marked Nos 9, 15, 19, and 7 are reported as being provided on either side with a trough to which cattle are brought to drink, and the waste water from these wells is allowed to sink into the neighbouring soil I think a great objection to these drinking troughs for cattle in the neighbourhood of wells is that they bring to the well a number of the lowest and dirtiest class of Natives, and thereby expose the well to contamination

I believe that there is great necessity for re-arrangement of water-supply for the troops at Cawnpore, and that wells for drinking-water should be provided at a distance from buildings, and should be guarded from use by all but the beasts attached to the barracks

Since writing the above, I have received the Report of the analysis of the Cawnpore waters, which were made by Dr Compigné in October and November. I can only identify one well water analysed by him with any analysed by Dr Milne, and that is the water of No 7 well.

Dr Compigné writes—"The Cawnpore waters are of interest and consequence as regards quantity there is quite sufficient, as regards the quality, the permanent hardness is too high, the total solids and volatile matter are both high, as also the mineral matter, the Chlorine is also in some amount Owing to my having had some idea of being sent in charge of the 12th Bengal Cavalry, the examination was necessarily made in a hurried manner, and some points which were omitted, I must send the information of, as soon as I receive it "

From the foregoing account of the water-supply at various stations, some general considerations may, I think, be usefully drawn as regards the peculiar dangers to which the water sources under consideration are liable, and the means which should be taken to prevent their occurrence, and

first, as regards the water-supply from wells. The well-water may be unwholesome owing to the nature of the soil of the water-bearing stratum from which it is supplied, for, independently of all sewage pollution, this may contain so much saline matter, or saline matter of such a nature, as to charge the water percolating it to a degree which renders it unfit for consumption, and in this case the supply can be amended only by sinking the wells till a more favorable water-bearing stratum is reached.

Then, in other places, though the water in the wells may naturally be very good, the soil being of such a nature as to yield a minimum of solid matter to the water percolating it, yet the supply may become polluted by the neighbourhood of Latrines, Urinals, collections of filth, or animal or vegetable refuse, or, perhaps, to a less degree, by the proximity of Cook-rooms, Wash-houses, and other buildings. Another source of danger of the same kind, and one very common to this country, is the proximity to the well of a dirty tank, such as is probably used for washing clothes, and bathing animals of all kinds, including man, sometimes the most dangerously dirty of all the water in the tank becomes in the hot weather very low, and horribly foul, yet so long as it holds water it will aid in feeding the supply of the neighbouring well

Wells belonging to hospitals seem to be very liable to contamination, it may be from the drainage of the surface on which the buildings stand, but it is not to be wondered at, that proximity to any buildings in India should influence the water of a neighbouring well, for the multitude of native servants who are employed, always finding an open door or a window handy, will throw refuse of any kind out upon the ground. The perusal of the analyst's reports puts it beyond a doubt that many of the wells on which they have reported are very dangerously placed, and such wells should, I think, be disused, even though the analysis of their water fails in bearing definite

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evidence against them, for while an immense mass of evidence goes to prove that contaminated water is a positive cause of disease, it cannot be said that science in the present state of chemical analysis, is always able to detect the poisonous matters in the water, and therefore liability to contamination is the point first to be considered in judging of the fitness of a water for human consumption

The causes of contamination that I have mentioned are those to which wells in all countries are, to a greater or less extent, subject, but the peculiar habits of Orientals give rise to sources of contamination which do not exist in European countries. Thus, when a native comes to a well, he does so to wash as well as to drink, and probably the first thing he does, will be to sit on the edge of the well with his legs dangling into it, draw some water with his lotah, or, if he is poor, with any old tin pot improvised for the occasion, wash his mouth, face, hands, and legs, and after this, having taken a drink, he goes about his business, unless it strikes him that his cloth is unusually dirty, when he will wash that too, and even if all this is not done over the well, it is done by its side, and the washings find their way, but by an indirect route, back to the well. Then to some of the wells, cattle are brought to be watered, and with them come their attendants, dirty to a degree, and just having issued from a foul stable, or more filthy hut which they may be occupying with a cholera-stricken companion. Where they have been sitting, a friend or the bheastee throws down his pot or his water-bag, or rests his mussuck, and dirt which adheres to these implements in all probability goes down into the well. Or it may be the bheasties or the servants, fresh from travelling with their naked feet the Cholera ward of hospital, stand upon the edge of the well, or on the wooden platform over it, and as they draw the water, the droppings wash the dirt from their feet into the well beneath.

If, as I believe is undoubtedly the case, the wells are liable to contamination from such circumstances as those I have mentioned, it is necessary that certain rules should be laid down, and acted upon, for their construction and protection. First of all, it should be decided, from the results of experiment upon the waters of existing wells, to what depth a new well should be sunk to ensure a constant, and, as far as possible, naturally pure supply of water, and in deciding on the position of a new well intended to supply drinking-water, a distance of 40 or 50 yards from any building, or drain or badly kept well or tank, should be insisted on. In regard to the construction of the well, it should be what is ordinarily called a "pucka" well, and the masonry should rise above the level of the ground or platform, at least two feet, forming an encircling wall to the well mouth, and the wall should be surrounded by a masonry platform at least six feet in breadth on every side, and terminating in a drain which should lead the waste water away from the neighbourhood of the well. Unless a pump is used, the water should be raised by means of a windlass provided with a chain and metal bucket, and lastly, the well supplying drinking-water should be strictly guarded, and none but the bheasties should be allowed access to it. But what a waste of labor and time does this method of drawing water involve, and how much safer and better in every way it would be to have none but covered wells, each provided with a pump, instead of the open wells, worked as now with the windlass, or the simple rope and leather bag, and the saving of labor is perhaps a small consideration in comparison with the security from pollution which the less primitive plan would confer. No doubt, the day will come, when a still further advance will be accomplished, and the barracks throughout the country will be supplied, as are those in Fort William, by means of pipes laid on to the building and kept supplied on the high pressure system by means of machinery.

Tanks—Tanks are largely used in the Lower Provinces as reservoirs of water, but not nearly to so great an extent in the Upper Provinces, where the use of wells predominates. The water of the tank, like that of the well, varies in purity with the nature of the soil in which it is dug, but is not so much affected by this cause, as a great part of its supply is derived from the direct rain-fall. Besides direct rain-fall, the sources of the supply to a tank are surface springs, percolation through its sides, and the water which is collected and poured into it by surface drains.

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Tanks are liable to be polluted by the same causes as are wells, and they are more difficult to guard; but their water, unless artificially contaminated, is generally more pure than that of neighbouring wells. In the case of a tank which is in part fed by surface drains, great attention should be paid to the direction the drains take and to the nature of their gathering ground. If, as in some cases, this is a bazaar, it is evident that the water which flows into the tank must be horribly impure, loaded with much of the debris of the filth which has been accumulating upon the ground during the eight or nine previous months. In the case of some tanks, as for instance those which supply Fort William, it is perhaps necessary, in order to fill up the tanks, to collect the water by means of drains from a large extent of maidan, but when this expedient is necessarily resorted to, the first washings of the ground and drains should be permitted to escape in another direction, and only when the ground has been thoroughly washed should the surface water be led into the tanks. If there be two adjacent tanks, one should be made a settling tank, in which the water may be allowed to clear prior to its being led into the other tank. In the case of a very large supply of water not being needed, it would be well, as has been lately done in the case of the General Hospital Tank, to close all surface drains, and to allow the tank to fill, as far as can be, by direct rain-fall, and by water, which percolating through the soil is filtered and made to undergo a certain amount of oxidation, and the banks of the tank should be provided with a reverse slope by raising the edge a foot or two above the level of the surrounding ground. The tank of drinking-water should be fenced round and guarded, and no one, excepting the bheasties, should be allowed access to it, but it would be far better than the bheasties also should be excluded, and that they filled their water bags from cocks supplied by a filter as at the General Hospital.

Filters—From whatever source the drinking-water is taken for Barracks and Hospitals, it is ordered to be passed through filters before use, a very necessary arrangement, for the water, as it is brought by the bheasties, almost always contains a considerable amount of suspended matter. This is especially the case with tank water during the rains, and even during the dry season the water is apt to become muddy, owing to the bheasties and others stirring up the mud at the ghaut while filling the water bags, or taking water for their own use. Well-water suffers in the same way, for, disturbed by the constant agitation of the vessels let down into it, the suspended matter cannot subside, and if the water is low, the mud at the bottom becomes stirred up.

The filters now in use in all the Barracks and Military Hospitals are on one pattern, consisting of three earthen-jars supported on a stand one above the other, these jars are half filled with wood, charcoal and sand, and each is pierced below with a hole, through which a tag of linen guides the water as it filters into the mouth of the vessel next beneath, from the third vessel the water falls into another usually of a larger size, in which it is stored for use, and from which it is taken by means of a pot of some sort dipped into the jar. A row of such Filters stands in the Hospital or Barrack verandah, or in the wards themselves. In one hospital I have seen them placed immediately outside the Cholera ward, four or five yards distant from the beds.

The objections to this form of filter are very numerous, in fact, the plan is bad every way—

- 1—The vessels are all open, and not only do insects and dust—the sweepings of the ward—fall into them, but they are free to receive the germs of disease which may be floating in the Barrack room, or more especially in the Hospital ward, while the water must absorb a portion of any noxious gaseous emanations present in the air.
- 2—The organic and other matters suspended in the water collect in the ghurrahs, especially in the upper one, and there decomposing and becoming soluble, add to the amount of soluble organic matter already present in the water, indeed, unless the filtering material is very frequently changed, and the vessels each time are well cleansed, this may become a very serious evil. As the vessels are porous, it is difficult to cleanse them thoroughly.

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3.—The water is removed from the lower vessel only by dipping a pot into it, and either the pot or the hand may, and very frequently will, soil the water, especially if ward coolies are employed, but further, the water is only occasionally changed, and the sediment which sinks to the bottom of the storage vessel must slowly contaminate the residual water, which, in its turn, infects the fresh water dropping in from above

4 —The filtering medium is bad,—in fact useless, unless for removing the coarser suspended matters

5 —The trouble that is necessary in cleansing the filters and changing the material, is such, that the work is often too long neglected

These are no fanciful objections to the present description of filter, they must appear obvious to any one who will give the matter a little serious consideration, and the reports which I have received from the analysts concerning the filtered water they have examined, proves them real. Almost always, as a rule, the filtered water contains more organic matter than the water from the source, and the water in the upper vessel more than either. The water in the upper vessel was in many cases found to be swarming with mosquito larvæ, and other animalcules, and has been described as filthy stuff. Mosquito larvæ and other animalcules are very commonly present in the water of the lower vessel. The water from a storage vessel, which I examined, had so strong a smell of a muskrat that I feel sure one must have fallen into it.

The present filters are indeed so manifestly bad, that the wonder is, they have been so long retained

The requirements of a good filter are as follows —

- 1st —That it should deliver an ample supply of water
- 2nd —The arrangement of the filter should be such, that the suspended matters in the water may not collect upon the filtering medium
- 3rd —The filter should not, as any part of its arrangement, contain an open receptacle, exposing the water to the air of the chamber in which the filter is placed
- 4th —The means for drawing the filtered water should be by a cock
- 5th —The filtering medium should be readily removable

6th —The filtering medium should be altogether, or in part, well burnt animal charcoal. perhaps the only substance with which we are acquainted which can, to any great extent, remove dissolved organic matter. Regarding the use of animal charcoal as the filtering medium, I quote the following remarks from extracts of letters from Dr Frankland, which are published in the Registrar General's Report for 1866 —“I should prefer filtration through animal charcoal, which, as you will see from my three recent reports, removes practically all organic matter, one-half ton of animal charcoal would be required for each 1,000,000 gallons sent out daily. The animal charcoal should be in grains about the size of blasting powder, and the filtered water would simply have to pass through the mass of this charcoal contained in a suitable tank. The London Water Purifying Company, between the entrances to King's College and Somerset House, use this material, and it is through one of their filters that the new river water passes for my monthly determinations. I think after all, that such a mode of purifying the whole of a Company's water is, by no means, an insuperable undertaking. The charcoal will continue to act for six months at least. It is the charcoal used by sugar-refiners, and care should be taken that it is fresh, and has not been already used.”

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There is indeed another substance, namely, the so-called magnetic Carbide of Iron for which the inventors claim the property of separating organic matter from water, but the power of the Magnetic Carbide to do so has been questioned, and moreover, the expense of purchasing and bringing out to this country the Magnetic Carbide in sufficient quantity would be an objection to its employment, when that is put in comparison with the use of Animal Charcoal, for Animal Charcoal is a substance which might be prepared quite as readily and as cheaply in this country as in England, and besides, its powers may be renovated by simply subjecting it to re-combustion. It is indeed to me a matter of surprise that the use of animal charcoal has not been long since introduced for the filtration of the water in Hospitals and Barracks, for its value has been over and over again established by the experiments and observations of the best authorities on the subject, and it alone (excepting perhaps the Magnetic Carbide) of all filtering media can do more than remove the suspended matters. No doubt, Animal Charcoal will not remove all the organic matter from impure water, it may not be able to remove the cholera poison, whatever that may be, but its purifying effect is unquestionably so great, and it is so readily applicable, that in my opinion it only remains to decide as to the form of the filter in which the charcoal should be used.

The only filter I have seen, or read of, which combines all the requirements I have mentioned above, is the so-called Danchell filter, which is now in very large use by the London Filtering Company, and is, as I hear, being fitted on a large scale to the Government Asylum at Broadwood in England. The principle of the filter is very simple, it may be described as a syphon, the shorter limb of which is expanded into a chamber packed with animal charcoal, the larger limb of the syphon is fitted with a stop cock through which the water is drawn off as required, and there is an arrangement by means of which the rate at which the water filters through the charcoal can be increased or lessened. The charcoal in the chamber can be easily removed, and the chamber re-packed with fresh charcoal, or with the old, after it has been re-burnt. The filter may be placed in any cistern, but a zinc or iron cistern commonly supplied with the filter. The filter is supported in the cistern at a short distance from the bottom. When water is poured into the cistern, the suspended matters gravitate to the bottom, and only the comparatively clear water comes into contact with the filtering medium. I think the filter might be still further improved, especially if the water to be filtered is very muddy, by placing it in a cistern divided by a partition, on one side of which the filter should be placed, while the other side should be fitted with a tray of sand above which the water should be poured, and through which it would consequently have to pass before reaching the filter itself. The sand upon the tray should be changed every, or every other day. It is essential to remember that the purifying power of animal charcoal depends upon the property it possesses of condensing oxygen upon its surface, and it is therefore, necessary, that the charcoal should be frequently exposed to the air in order that it may absorb a fresh charge of oxygen. This, in the case of the Danchell filter, can be managed.

The Danchell filter not only fulfils all the requirements I have mentioned, but it has this additional advantage that its syphon-like construction enabling it to draw the water through the filter, aids gravitation in keeping up a constant filtration, and further, as it keeps the filters full throughout, nothing can enter without first passing the filtering medium. Danchell's filters in a covered cistern should be placed in every Hospital and Barrack ward. The prices of the filters, as advertised by the Company, are as follow —

	£	s	d
" Filter No 1, yielding $\frac{1}{2}$ a gallon per minute	1	10	0
" " 2 " " "	2	0	0
" " 3 " " "	3	0	0
" " 4 " " "	4	10	0

One of these filters has been in use for about a year in the Medical College Hospital, and I subjoin the results of some experiments I made, with a solution of permanganate of potash, with a view to testing this filter, and comparing it with the ordinary ghurrah filter which is working side by side with it in the Hospital, both filters are supplied from the same source, a tank in

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College Square At the time of experiment, the Danchell filter was delivering three quarts per minute, the charcoal in it has never been changed, probably if it had, the results would have been still more strongly in favor of the Danchell filter

Quantity of permanganate solution (2 grains in 20,000 added to 10,000 grains of the water acidified with 30 minims of Sulphuric Acid, to obtain a color permanent during 15 minutes

	Grains
Water from the tank	160
Water from the upper ghurrah of the old fashioned filter	170
Filtered water from the ghurrah beneath	210
Water from the cistern of the Danchell filter	190
Filtered water from the Danchell filter	50
Distilled water as received from the Medical Store Department	55

There are now several of the Danchell filters in Calcutta, and doubtless one could easily be obtained for trial in any Government Hospital, should Government entertain the idea of using this filter upon a large scale

At the General Hospital, the whole of the drinking water is filtered by the side of the tank, and undergoes no further filtration in the wards. The filter is thus constructed. By the side of the tank stands a circular masonry tower, the interior cavity of which is 15 feet high, by 10 feet in diameter. The top of the cistern is dome-shaped, and the arch of the dome is 5 feet in height. The lower 2 feet of the tower is blocked up with masonry, above this is a cistern 2 feet in height, the roof of which is of perforated paving stones, and on these rests the filtering medium—first, 8 inches of coarse broken brick, then as much fine broken brick, above this 2 feet of fine sand. The water is pumped into the tower by a Californian lift-pump, half an hour's pumping suffices for 24 hours' supply. The filter is provided with a gauge which shews the amount of water in it, and the daily consumption. In October, about 300 people consumed 210 gallons daily for drinking only. The water for cooking and washing is taken direct from the tank.

The water is drawn from the filter by means of four stop-cocks, the pipes from which enter the tower upon its floor and the cocks are 2 feet above the level of the ground, below each cock is placed a sloping board upon which the bheastee rests his mussuck while filling it. The spilled water is carried off by a masonry drain which surrounds the tower, and carries the water into the hospital drains which lead to the outside of the compound. This filter has now been working constantly for nearly a year, the water from it is perfectly clear, bright, and tasteless, and 10,000 grains of it acidified with Sulphuric Acid, consumed only 90 grains of permanganate solution. The water from the tank consumed 190 grains, and that from the upper compartment in the tower, 200 grains. This filter would be much improved by placing a layer of animal-charcoal 2 feet in thickness between the sand and the very finely broken brick, and I think that the top of the tower, instead of being dome-shaped, should be flat and covered by two iron-flaps. The filter should be cleared out once a year, but as it is at present constructed, this could be done only by taking down the masonry dome. The objection to the use of such a filter, as the one just described is, that the water has to be carried from it to the wards in the bheastees' water-bags, and it must be stored there, and may be placed in an open and otherwise unfit vessel. The small filter in each ward would, it seems to me, be a very preferable arrangement. I think it should be the rule as regards all filtering arrangements, either that the water should be filtered by the side of the tank or well, and should then be distributed at high pressure over the Barrack or Hospital, or that it should be filtered in the ward through such a filter as the Danchell's, but on no account should there be any storage of filtered water in open vessels, especially if it is required for use in the wards of a Hospital or Barrack.

It is evident from the reports that have been already received from various stations regarding their water supply, that the supply is not so guarded as to prevent the risk of its infection by the poison of Cholera, and of other diseases, and the question arises, in what way may this occur under the circumstances that have been described? It seems probable that water may become the propagator of Cholera by disseminating Cholera excreta which have found access to it, and this has, I

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think, been abundantly proved by the investigations of Dr Snow and others, who have followed in the same path of inquiry. Certainly, if the evidence, these investigators adduce in support of their view is not absolutely conclusive, it is sufficiently strong to make it reasonable to act as if it were so, in considering the arrangements for the supply of water to a very important section of the community. So strongly, indeed, is this opinion held by some high authorities on the subject that, in a leading article published last year in the *Medical Times*, the writer says—"So that the occurrence of a single case of Cholera on the banks of the Thames, the sea, or any other obscure river from which the London water supply is derived, may, at any moment, diffuse the cholera all over the Metropolis," and, if this be a true statement of what may occur from the mingling of cholera discharges in even a very minute quantity in drinking-water, the present mode of supply to our troops must be full of danger. And the danger is the greater, because neither chemical nor microscopical research can detect the poison even though it be present in fatal quantity, and further it is most unquestionable that the means at present employed for the removal of the poison are worse than useless. Whatever this poison may be (whether living matter of a low sort, as Dr Beale holds, or matter in a state of change as Liebig supposes, or as Dr Richardson has still more recently surmised, an alkaloid), if it be placed in pure well-oxidised water, it will more or less quickly decay and vanish, and I believe, much would be accomplished towards this most desirable end by passing an infected water through animal charcoal, for this method of filtration may destroy the poison by causing its oxidation, and if it should not effect this, yet it would certainly so purify the water from organic matter that the poison, if of the nature of living matter, would probably die for want of pabulum. But though it is not possible either to detect the Cholera poison in water, or with certainty to remove it if it be present, there is much comfort in the consideration, that by the use of properly placed and protected wells and by delivering the water upon the constant system, avoiding its exposure by storage or otherwise, we altogether prevent, or, at any rate, reduce to a minimum the danger of contamination. On the other hand, if the wells for the supply of drinking-water are dug in unprotected ground, if we leave the wells uncovered, and allow them to be indiscriminately frequented by servants and passers-by, if cattle, with their attendants, come to water at them, if all frequenters may wash themselves and their clothes by the well side, or while for the purpose of drawing the water they may use any utensil they please, and if no means, or very inadequate means be taken to prevent the return of the fouled water to the well, then we do, indeed, increase the risk of contamination to a very great degree, and perhaps bring it to a maximum when we expose the water in the hospital wards in an arrangement which might more justly be called an infection trap than a filter.

Then, again, water may become a propagator of Cholera, if contaminated by sewage, the sewage either containing the germs of the disease, or, when received with the water into the alimentary canal, serving as a congenial soil in which any germs happening at the same time to find their way there, can vivify and increase. Whichever view be adopted, it may now be laid down as an indisputable fact, that sewage received into the alimentary canal is a very potent agent in the production of Cholera, and this though it is in a very diluted state. Indeed, we can readily understand that, if the poison partake of the nature of germinal matter, no amount of dilution will render the water to which it finds access innocuous, the dilution only diminishing the chances of the poison being received into a system in which it can find the conditions necessary to its development and increase. There is this to be said regarding a mixture of Cholera poison and sewage, that though we cannot, by any test, detect the one, we can, with a very considerable degree of certainty, recognise the presence of the other, and even though the sewage may be present in very small amount, we can, by the use of proper means, establish such a probability of its existence as is abundantly sufficient to the act on. For some time past, reliance has been placed on the use of permanganate of potash for the detection of sewage matters in water, the permanganate affording and indicating the amount of oxygen necessary to destroy the putrescible matters present there, and, though this test has been disparaged by Dr Frankland, I cannot but still place much value on its use. Dr Frankland's objection to the test is, that the permanganate has little or no action upon such bodies as Sugar, Gum, Gelatine, Hippuric Acid, Urea in solution, but then it is to be remembered that these bodies are much higher in the scale of organic products, and of a much more stable nature than the putrify-

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ing, changing matter into which excreta are resolved when exposed to the action of air, and moisture, and soil. It is a fact that, under such circumstances, sewage does largely yield readily oxidisable matter, which is quickly acted on by permanganate of Potash (hence our use of that substance as a deodorizer), and I, therefore, still believe that the permanganate test is not only a ready, but a very valuable means of detecting sewage impurities in water, only its results must not be taken alone, for it is no doubt a fact that water may decompose a large amount of permanganate owing to its containing readily oxidisable organic matter of a comparatively harmless nature. In such a case as the following, the indications of this test must be taken to be of great importance. The physical properties of the well waters of a station are alike, and may be unexceptionable, but one of the waters consumes much more permanganate than the others, in such a case we may, I, believe, be very confident that the well is somehow or other contaminated, and the suspicion will be increased almost to certainty if it is found that the well contains Ammonia, Nitrous Acid, or Nitrates, or Chlorides, or still more, two or all of these, in excess of the amount present in the other wells. The permanganate test may indeed fail, owing to a cause different from that which I have mentioned above, for as at Delhi, though the soil may receive an immense amount of sewage, yet its oxidising power may be so great that none but the products of the complete oxidation of the sewage, namely, Nitric Acid, may reach the well water, and doing so indicate not the present pollution, but the liability to pollution, should a direct passage be open for the sewage by any chance, but then in this case, the presence of an amount of nitrates far in excess of that in the wells of extramural Delhi indicates very clearly what is occurring.

As a very decided proof of the ability of the means we are now employing to detect impurities, especially sewage, in water, I would adduce the comparison of some of the Hazarcebaugh wells with the well in the bazaar at the same Station. The circumstances of the wells are precisely the same excepting that this one well is surrounded by a bazaar, and the record of the analysis of its water is such, that any sanitarian would at once have pronounced the water polluted, though he had no knowledge whatever of the site of the source whence it had been taken. And though the allowed imperfection of our means, and sometimes want of care or ability on the part of the analyst may cause a failure in the detection of an impure water, I am satisfied that very valuable results will accrue from the labors of the present analytical commission, both in the way of the detection of unwholesome water sources, and of possible causes of pollution. Of this I am assured that there is much bad water in use by our troops both European and Native, and that there has been a lamentable want of foresight in the disposition of tanks and wells, or of new buildings in proximity to old water-sources, but these things were done before the experience and investigations of the past few years had shown that bad water, and many diseases, especially cholera, stand to one another in the relation of cause and effect, but now that we do recognise this relationship, there is no excuse for the man, official or non-official, who digs a well near a privy, or empties his refuse into a pit beside his house well, or leads the washings of a bazaar into the tank from which drinking-water is supplied. Such a procedure is almost criminal in its carelessness, and since we know by ample experience that cholera will fix itself, and will spread wherever sewage contaminated water, is in use, the bare suspicion of such contamination should be at once acted on, and the more readily, because there are very few places in which it is impossible to obtain wholesome water, and to obtain it without resort to any very extraordinary measures.

Office Memorandum from the Secretary to the Government of India, in the Military Department,
to the Secretary to the Government of India, Public Works Department, dated 9th July
1868, No 181.

The undersigned is directed to forward to the Secretary to the Government of India, in the Public Works Department, the accompanying Report by Dr Macnamara, on the water analysis, during 1867-68, at the several large Stations in Bengal, with the view of precaution being taken to

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prevent the pollution of wells in Cantonments which are used for drinking purposes, so far as may be practicable, and also to the adoption of such measures as may appear to be feasible for sinking new wells where it may be found desirable.

2 His Excellency the Governor General in Council, is also of opinion, that where river water is available, it will be worthy of consideration whether arrangements should not be made for a tentative use of such water.

3 Special attention is requested to the remarks on the Dinapoor water at pages 12 to 14 of the Report.

No 399. ORDER THEREON, 22nd January 1869, No. 200.

MILITARY WORKS, No. 30.

Communicated to the Superintending Engineers for attention.

(True Extract.)

Colonel, R. E.,
Secretary to Government.

To the Superintending Engineers
,, Captain R. B. Kennedy
,, the Sanitary Commissioner.
,, Military Department

Edw G. A. Turton.

Cort. of 1869: Madras.

PUBLIC WORKS.

To

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Potable Waters —Circular from the Government of India forwarding, for attention, copy of a Report by the Chemical Examiner to Government on the Analysis of Potable Waters of Cantonments, communicated to the Superintending Engineers &c.

Enclosure to Circular No. 92 Public Works,

Dated 18th December, 1867

From—F N MACNAMARA, Esq, M D, Professor of Chemistry, Bengal Medical College,
To—Secretary to the Inspector General, Lower Provinces

I have the honour to report upon the work of the Medical Officers who were engaged during last April, May, and the early part of June, in analysing the potable waters of the Military Stations named in the margin, and I have added the reports which I have received on the analyses made during the past rains in the eight last-named Stations. Owing to the absence, on sick leave, of Dr Larkersteen, no further progress has been made in investigating the water-supply of the Central Punjab Stations. Dr Murray Thomson was prevented by his duties at Roorkee from visiting the Hill Stations during April and May. He is, however, now engaged in the work, but as it is highly desirable that the waters of those Stations should be examined before the commencement of the rains, I beg to suggest that one of the Medical Officers, who have had the necessary experience elsewhere, should be deputed to the Hill Stations during the next hot dry season.

Dr Center, who was to have been employed in analysing the waters of Campbellpoor, Rawul Pindee, and Peshawur, was able to accomplish the work at the latter station only, for, owing to the outbreak of cholera during May, his services were urgently needed in the detached camps. Dr Orton, who was detained in Lucknow by his duties as Officiating Sanitary Officer of that city, was unable to visit Fyzabad and Seetapoor, and Dr Jameson was prevented by his duties at the Doyal Jail from proceeding to Benares till long after the rains had set in, his report, therefore, upon the waters of that Station will appear in the report upon the autumnal analyses. These and other changes in the analytical staff have interfered considerably with the progress of the work. Still a great deal has been accomplished, and I feel confident that reports of even greater value, and more completely reliable, than those hitherto sent in, will be obtained when the exigencies of the service allow of the continued re-employment of those Medical Officers who evince taste and ability for this very special duty.

The value of a water-supply report depends not solely, or indeed chiefly, on the great accuracy of the analyses it includes, but mainly upon the truthfulness of the picture it presents of the condition of the water-supply of the station, pointing out where it is liable to contamination, (either as a whole, or in any of its separate sources), and how far it is capable of improvement. But to ensure such a report minute and well directed enquiry is needed, and enquiry of a nature which Medical Officer new to the work and fresh from Home will necessarily find a difficulty in instituting, and it is evident from the experience of the two past seasons that, as might *a priori* have been expected, the analyses differ very much in their aptitude for this special work, though all exhibit an amount of technical knowledge that would not have been looked for in Officers who entered the service before the establishment of the Netly course. No doubt these gentlemen receive the best course of training, it is possible to give them short of an independent course in a working chemist's laboratory, still I fear that not a few of those who are thus trained will fail when thrown upon their own resources, for as many a man who has passed in anatomy fails altogether as an operative Surgeon. My experience as a teacher of practical chemistry is, that very few individuals out of a large class have the qualities necessary to make them successful analysts. Very few will be found to have really any taste for chemical analysis, many students appear incapable of recognising any error, or source of error, which accidentally obtrudes itself in even the simplest processes, while if error is possible, they fall into it, and other students wanting in perseverance and exactness, readily content themselves with an imperfect result. Other deficiencies might be mentioned which must give rise to failure when such students are thrown upon their own resources, especially if they have to employ processes and apparatus to the use of which they have not been trained. If a man has a taste for analytical chemistry, it is highly probable that he possesses the natural qualifications for that work, and he will certainly take pains, when opportunity offers to become proficient in it, and I therefore think the plan pursued in regard to one batch of Assistant Surgeons, which arrived at Calcutta, might very advantageously be pursued with others, and that volunteers for employment on the analytical staff should be called for, and that those gentlemen who register their names should be preferentially employed when the exigencies of the service permit of any selection being made.

Apparatus —The twelve sets of chemical and apparatus indented for from England reached Calcutta in time for distribution in April last. The apparatus was generally well chosen, and well adapted for the work, but the boxes appeared to be of unseasoned wood, and the screws might with advantage have been more freely used, in the place of glue, in fixing the partitions. Unfortunately, the most important piece of apparatus in each set, namely, the balance, is decidedly inferior, clumsy, roughly made, difficult to get into good working order

and very apt to give wrong indications unless used with the most extreme circumspection. I received many complaints from every one of the analysts regarding the want of accuracy in the balances, and it is on that account that I have not laid stress upon the reported results obtained by ponderal analysis in any case in which very accurate weighing would be required to establish them. I have circulated among the analysts most minute directions for using the balances, and I hope that, by the aid of these instructions, inaccuracies may, as far as is possible, be avoided, but I am decided in my opinion that the balances are unfit for their intended purpose, and it will be most satisfactory to learn that the application I have already made for their re-placement has been sanctioned.

I commence the report upon individual stations with that on Peshawur—the waters of which were examined by Dr Center in May and August. Dr Center reports as follows—

“The water-supply of the Station of Peshawur is from two sources—from wells, and from a cutting from the Bara River, made by the Sikhs.

Sources of water supply

“The native troops use the stream water only, the British troops employ both sources. The wells are very deep as the station lies on a long ridge of low elevation, sinking away towards the east, the water-bearing stratum is not far from the surface. The ground towards the east of the station, from about the lines of the 13th Bengal Cavalry towards the Fort and the city was a grave-yard, and an extremely crowded one. On simply raising the ground with a stick, fragments of bones are seen. On enquiry of natives and Europeans as to whether the west and greater part of the station was a grave-yard or not, conflicting accounts were received. From trials of the soil, it seems most probable that there were small isolated grave-yards of one or more hamlets.

“The stream flows from west to east through the station, dividing laterally into two branches. Secondary streams run off into Regimental tanks, others irrigate the compounds, others flow through the bazaars. The water is liable to be polluted on the main, or sometimes even more on the secondary streams. It is notorious that they are polluted, in consequence of the careless and disgusting habits of the natives. To guard against this, the tanks are usually filled at night. It is recommended that main streams should be protected by a fence or a mud-wall. The Regimental Authorities should see that the streams going to the tanks be as short and well protected as possible.

“This stream enters the station from the west and flows through it. Cuttings are made to the Regimental tanks as it passes the line, others are made through the compounds for irrigation, and for filling smaller tanks, others run through the bazaars. Thus, it supplies water for three purposes, for drinking irrigation, and for carrying off sewage. The soil, &c, of the station is removed by carts.

“About the middle of the station the main stream divides, the two branches acting as main streams, and giving of secondary branches. The water is made to run through different parts of the station at different hours if the stream is low.

“The main stream is quite unprotected by walls or otherwise. It flows through compounds, and at the roadsides laterally, native houses are built close beside it, and cattle are kept close to it in various places. It is quite common to see natives washing their bodies and utensils in it. A pucca drain is made from the wash-houses of the 77th Regiment direct to the main stream.”

In a letter to me Dr Center writes—“Further, as an instance of how the water might be polluted, while in company of another Medical Officer, I observed a native suddenly taken ill, vomiting within a few feet of the bank of the main stream in the 42nd lines.”

I find the following notice of the water-supply of Peshawur in a report on the epidemic visitation of cholera in the 93rd Highlanders by Dr. Munro, the Surgeon to the Regiment, published in the Sanitary Report of the Army Medical Department for 1862—“The Bara supplies the station and city with water for all purposes of domestic use and irrigation, and its waters are led into Cantonments through artificial channels that traverse every street, pass close to all public buildings, and run through every garden or compound. These channels are simply ditches, and, in most instances, on a plain higher than the foundation of the houses, they are neglected, dirty, frequently choked up with mud, which is often exposed for hours and days, when the water is cut off from the locality, and turned off in another direction. There are miles of these ditches within Cantonments, and one of the largest and dirtiest runs close past the barracks and hospitals, its bed being higher than the foundation, and also close past the barracks occupied by the 93rd, its bed being higher than the foundations of the barracks. The Artillery barracks are almost enclosed by such ditches. A considerable stream from the same river flows through the city of Peshawur, which the inhabitants use for domestic purposes, and into which all kinds of filth are thrown, and which appears to act as the main surface drain of the city.”

The stream itself was examined by Dr Center two miles above the station. He found the water hard, and containing a considerable quantity of oxidisable organic matter; ammonia and nitrous acid were also present. The water contained no large amount of dissolved constituents, and if the stream could be kept clean and unpolluted, it would yield a very fair drinking-water.

Dr. Center next examined the water taken from the tank which supplied the 77th Regiment. This tank is filled by means of a water-course about 20 yards in length, connecting it with the main stream. Just below the barrack yard is a Corn-mill, turned apparently by the stream, but, however this may be, the vegetable refuse from the mill is thrown upon the ground near the banks of the stream, and there decays. Until lately (indeed at the time when Dr Center commenced the examination of the station waters), the drain from the Regimental wash-houses opened into the stream just below the mill, and added its quota of pollution to the waters. From analyses it appeared that the tank water resembled that of the stream higher up in its course, but contained nitric acid in addition to ammonia and nitrous acid, and an increased quantity of chlorides.

The water from the tank belonging to the 45th Native Infantry was next examined. The tank is fed by a leader from the main stream, and also by the drainage of the parade-ground, it is sheltered by trees, the dead leaves from which fall into it, and at the time of Dr Center's visit, it was covered by a mat intended for its protection, but old and useless, and partly immersed in the water. The water of this tank resembled that of the tank belonging to the 77th Regiment, but contained more oxidisable matter, and a larger amount of common salt.

The tank of the 13th Bengal Cavalry is connected with the stream at a point still lower in its course, this tank is reported to be well kept, but connected with the stream by a channel which meanders amongst native houses and in close proximity to the place where the horses of the Regiment are stalled. The water closely resembles that of the tank of the 45th Native Infantry.

The hospitals of the 42nd Royal Highlanders and of the Artillery are supplied from Mackeson's well, the water of which is considered very good. The well is 100 feet deep, and yields an ample supply of water, it is imperfectly protected by a roof supported on four pillars. Apparently, the ground about the well is carefully guarded, but the mud lately removed from the well should not have been placed over the surface of the surrounding enclosure. The water, as shown by its analysis, may be considered a fairly good specimen of well water, it contains traces of nitric acid and ammonia, which may have a questionable origin, if, as I have been lately informed, the space where the well is, was formerly a grave-yard.

The Artillery are supplied from a well about one mile north of the station. This well is only eleven and a half feet deep, yet it always yields an abundant supply of water, for the level of the land falls considerably towards its locality, and surface springs occur in the neighbourhood. There are old graves all around the well, and the place is a favourite resort for dhoobies, the practice of whose craft had, at the time of Dr Center's visit, resulted in the formation there of numerous stagnant pools of water. A fakir who lives at one of the neighbouring tombs, and is apparently the guardian of the place, reported well of the water, and probably would continue to do so, even though he understood the purport of the nitrous and nitric acids and ammonia which the water contains. What with graves, dhoobies, and the visits of unwholesome pilgrims who resort to the fakir's, the well must be a perilous one to those who are compelled to drink its water.

The Jail well is about 50 feet deep, it is situated in the Jail-yard, water is raised from it by a Persian wheel, and flows from a spout into a small masonry cistern filled with stone and charcoal, and thence into a second similar receptacle, but the bheesties, possibly with a right appreciation of the value of the stones and charcoal fill the water-bags from the spout. Ghurrahs for dyeing purposes are stuck in the ground close to the well, and the waste water from the well, together with the refuse from the dyeing processes, runs to a neighbouring plot of grass where it stagnates and emits a most offensive odour. The Jail is built on the site of an old grave-yard. The water of the well is very bad, and the prisoners ought not to be condemned to drink it.

The water from the well in the Fort is very salt and bad, but it is used only by native workmen employed there. Water for the use of the guard is brought in by bheesties from a surface spring at the head of a drain in the neighbouring jheel.

The water-supply of Peshawur is “generally considered wholesome.” If it is so, Dr Center cannot have correctly described it, but I suspect his description is fairly drawn, and I cannot but think that measures are urgently needed to supplant the present water-supply, either by means of an artesian well, or by bringing water into Cantonments by means of a pipe or closed aqueduct from the Bara River.

Ferozepoor—Dr D. W. Palmer visited the Station, and examined the water-supply, during last June, the weather at the time was fine, with occasional dust-storms, temperature 97° in the shade.

The Cantonments are entirely supplied with water from wells, which pass down through the sand. So far as the wells have been sunk (about 50 feet), sand only has been met with. The wells yield a plentiful supply of water, and the supply does not notably diminish during the hot weather. None of them, at the time of Dr Palmer's examination, contained much water, in general only four or five feet, and I, therefore, conclude that they are quickly re-filled by water percolating the soil.

The water of the station is generally considered wholesome, but it is apt to contract a peculiar smell after a dust-storm, the cause of which is not explained. Dr. Palmer believes, as the result of his analysis and enquiries, that, with the exception of the water of the

Artillery well the water of the Cantonments is of good quality. Unfortunately his analyses are in some points defective, and further enquiry is, I think, necessary before a positive opinion can be pronounced regarding these waters.

The European Infantry are chiefly supplied from three wells. One of these is in the Soldiers' gardens, surrounded with trees. Dr Palmer notices that it required a cover to prevent dead leaves falling into it. The physical properties of the water are reported good, excepting after a dust-storm, when the water acquires a disagreeable smell. The water contained a moderate amount of dissolved constituents, but the permanent hardness is very great, 9° on Clark's scale if the report is correct. Another of the three above-mentioned wells is No 81, it is not far from the Soldiers' gardens, and its water resembles that of the well just referred to. The other of the three wells, No 79, is situated in the European Infantry hospital compound, and close to the hospital buildings. This well is in the neighbourhood of the other two, about equi-distant from each of them, yet its water contains very much more dissolved constituents, more oxidisable organic matter, and double the amount of chlorides. I suspect contamination has ensued from its proximity to the hospital buildings including the cook-house.

The Artillery are, as appears from Dr Palmer's account, supplied by two wells, one No 73 in the lines, the other in the hospital compound. Unfortunately the reported analyses are very defective, but in both cases the waters appear to be very hard, and to contain a large amount of oxidisable organic matter, both waters also contained a large amount of dissolved constituents, the water in the hospital well nearly 57 grains to the gallon, that belonging to the well in the lines double the amount. Dr Palmer is unable to account for the large amount of dissolved constituents in the water of the last-mentioned well, but thinking it a very bad water, he wrote strongly recommending the Commanding Officer to discontinue its use for his men, and to employ in its stead the water from a well in the neighbouring Native Infantry lines. At the time of Dr Palmer's visit, the Artillery had been driven into camp by an outbreak of cholera.

The Native Infantry at the station are chiefly supplied by two wells, whose water resembles that used by the European Infantry. The nearest of these wells is about 700 yards distant from the well in the Artillery lines already referred to. Dr Palmer considers the water in the well of the Native Infantry hospital the best in the station, it contained, at the time of his analysis, only 15 grains to the gallon of dissolved constituents, but it contained nitrous acid, and a very large amount of oxidisable organic matter.

The only other well examined by Dr Palmer was that in the Fort; its water closely resembled that of the north well in the Native Infantry lines, containing a slightly larger amount of oxidisable organic matter.

I gather from Dr Palmer's report that there would be no difficulty in supplying Ferozepoor with a plentiful supply of fair well water, and the station is in this respect far more fortunate than Umballa, no doubt because of its proximity to the Sutlej, the present wells appear to be badly situated, being all adjacent to buildings. Better water should be provided for use in the Artillery lines and hospital, and I cannot but think it would be advisable to provide another well for the use of the European Infantry hospital at a greater distance from the hospital buildings.

Umballa—Dr D W Palmer examined the water of the Umballa wells in May and June, the weather at the time was hot and dry, only very general inferences can be drawn from Dr Palmer's analysis.

The troops at the station draw their supply of water from wells which are for the most part dug in or near the beds of the two branches of the Tangree Nullah between which the Cantonment is situated. The Tangree is not a perennial stream, and though in the rains it may suddenly become filled by a great flood of water, becomes quite dry after a fortnight's cessation of rain. One elbow of the nullah touches the northerly angle of the Cantonment, and here are the Artillery or Tangra wells, another elbow of the nullah approaches the east corner of the station, where are situated the more recently constructed Tangree wells. Between these two sets of wells, a distance of about three miles, stretches an aqueduct covered only in a part of its course. From the Tangree wells the aqueduct runs along the north-west face of the station in front of the Artillery and Cavalry lines, it then bifurcates, enclosing the European Infantry lines, and finally passing in front of the Native Infantry lines, terminates at the angle of the station.

The aqueduct obtains its chief supply of water from the Tangree wells, and receives a reinforcement from the Tangra wells, the water is raised from the wells, Persian wheels worked by bullocks.

The Native Cavalry lines are situated in the centre of the north-east front of the station, they are not, however, supplied with water by the aqueduct, but by detached wells.

The Artillery are supplied by their own wells near the bed of the Tangree Nullah.

The European Cavalry and Infantry are supplied by wells, or more probably cisterns, which are filled by branches from the aqueduct, these branches and cisterns themselves are open. A cistern is placed opposite each barrack.

The Native Infantry are supplied partly by the aqueduct, and partly by wells in their lines, but as the water in the aqueduct falls short in the hot weather, the men are at that season chiefly dependent upon detached wells for their supply of water.

The hospitals of the European Cavalry and of the Artillery are supplied by detached wells, the cistern of the European Infantry hospital is filled by a branch from the duct, the Native Infantry hospital has its own well.

As regards the properties of the water drawn from the Tangra and Tangree Nullahs, I gather from Dr Palmer's analysis that they are much alike, and of very fair quality, not containing more than twenty-five grains to the gallon of dissolved constituents, not injuriously hard, and not containing more oxidisable organic matter than is usually found in properly situated shallow wells. Unfortunately the supply which these wells yield is very limited, and they run dry if water be pumped from them continuously for many hours.

It did not occur to Dr Palmer to analyse the water in the cisterns, but he examined the water in the state in which it is drunk in the European Infantry and Cavalry barracks, both of which are supplied from the same source. Yet if Dr Palmer's analysis are correct, the water of the Cavalry barrack contains almost twice the amount of dissolved constituents present in the water from the Infantry barrack, both contain a very large amount of readily oxidisable organic matter, which Dr Palmer ascribes to the water entering the cisterns through uncovered ducts, but he makes no report on the state of the cisterns or barrack filters, and the fault may be in them.

The water in use in the European Infantry hospital is also taken from a cistern supplied by the aqueduct, but no report is made upon it.

The Artillery hospital well is in the Racquet Court. It yields but a limited supply of water, daily running dry by noon in the hot weather, the water holds in solution a considerable amount of saline matter, and is much harder than the water of the aqueduct.

The Cavalry Hospital well is within the compound, about 20 yards from the hospital buildings, its water contains a large amount of dissolved constituents, about 50 grains to the gallon, very much oxidisable organic matter, traces of ammonia, and some nitric acid, it is, I suspect, contaminated, owing to the circumstances of its position.

The water in the detached wells used by the Native troops contains much more dissolved constituents, and is much harder than the aqueduct water,—the water of the Native Cavalry Hospital is described as having a brownish colour, and an earthy taste. The well in the Native Infantry lines deserves particular notice, as its water is used by the sepoys when the supply from the aqueduct falls short. The water is very bad, containing as much as 92 grains to the gallon of dissolved constituents, its use is said to cause diarrhoea.

I believe it is an admitted fact that the water-supply of the Cantonments of Umballa is very defective, and that for the city, both very defective and very bad. Many reports have been made upon the subject, especially by a Committee of Officers appointed in 1851 to enquire into the matter, and again, in 1863, by Captain Crofton, R E, Superintendent of the Sutlej Canal Survey. In consequence of these reports the Tangree wells were opened in 1865, and they have greatly added to the available supply of water for Cantonments, but the supply is still deficient, and in the city and its neighbourhood the want of an ample supply of water is very much felt. To meet the deficiency three schemes have been proposed to bring water by means of an aqueduct from a point on the Guggur River, 21 miles distant from Umballa, or to bring water into the stations from two small lakes situated in the hills, about 22 miles distant from the station, but the cost of carrying out either of these schemes would be very great. The third plan is to construct an artesian well. As it seems most probable from a consideration of the situation of Umballa that an artesian boring would be successful, and would, at a comparatively small cost, furnish an adequate supply, this plan should, it seems to me, first be tried. Another argument in favour of a trial being given to this last plan is that, whether the boring at Umballa should, or should not, prove a complete success, the instruments and work-people might be employed in other stations where an artesian well would be an immense boon.

Delhi—The Delhi waters were examined for the second time by Dr Sheppard in May and June, and his Report, which I now forward, fully describes their state at the time of his visit. I need only notice his remarks upon the waters which are used by the European troops. The river water still maintains its character as the best potable water in the station, and in my opinion no other should be used by the troops in garrison. Dr Sheppard does, indeed, speak favourably of the water of the Putthur-Ghatti Well, which is used by the troops in the Fort, but I hold strongly to the opinion that the troops ought not to draw their supply of drinking-water from an unguarded public well, and if it is worth the expense and trouble to bring water from the river for the supply of the barracks and hospitals, I think the same water might be supplied to the European troops in the Fort also, at any rate for drinking purposes. If, however, the use of the Putthur-Ghatti Well is continued, Dr Sheppard's suggestions for its improved conservancy should be strictly attended to.

It is very evident from Dr Sheppard's Report that an efficient system for the filtration of the drinking-water at Delhi is much required, and settling tanks, which need not be of great size, should also be provided for use in the rains when the river water is rendered milky by the presence in suspension of finely divided clayey matters, but these settling tanks need be used only in the case of water designed for the drinking supply of the troops.

* Dr Sheppard is now employed in analysing and reporting upon the Umballa waters.

The following are Dr. Sheppard's remarks upon the principal wells, and upon the drinking-water in use by the troops —

"The Putthur-Ghâtti Well is situated close to the termination of the Western Jumna Canal. It is not overhung by any trees; to the east is a large mound composed of the debris of former buildings which were razed to the ground in order to make way for Railway works, to the south of the well is a rather large puddle of water and mud, the water being derived from the canal leakage, and from the spillings after drawing up the well water. There is no arrangement for draining this

"The platform of the well is too small, and the spilled water may either fall at once into the well, or soak into the earth around the masonry. On the whole, the construction and conservancy of this well are of the worst description

"The water, when examined in 1867, contained a smaller quantity of saline and combustible matters than it did at the end of the rainy season in 1866, the nitric acid had also decreased

"This is a most important water source, inasmuch as the supplies for the Artillery and the European hospital are drawn from it. Owing to the disadvantageous sanitary condition of the adjacent ground and the imperfect construction of the well, the water is not of good quality, but from the two analyses which have been made of it, I am of opinion that it is one of the best well waters in intramural Delhi, and further it is, I think, possible to improve this water a little by raising the masonry of the well 3 feet, and making a platform at the top of it 6 feet in diameter, the construction of an apron about 4 feet wide, raised 1 foot above the level of the ground with proper ridges, and a drain to carry away the spilled water into the canal lower down, broken ground to the east should be levelled and dressed, and no encroachment of buildings should be permitted"

Khyrattee Gate Well — This is situated in low ground. The shaft has been sunk in the sandy bed of the Jumna at a little distance from the city wall, the level of the ground inside the wall being several feet above the river bed. At this season of the year, there is no stream near the well, but in the rainy and cold seasons of 1866, there was one within 100 or 120 yards

The supply of this well is not depended upon the filtration from the river, for the water exhibits such a marked difference in composition as characterised by the large amounts of total solids, combustible matter, and nitric acid, but it is highly probable that the constitution of the water may be influenced in some degree by the proximity and fullness of the stream which, in the rainy and cold seasons, runs under the city wall

The presence of such a large quantity of combustible matter and nitric acid in this water is strongly suggestive of the entrance of the city drainage by percolation into this well at all seasons of the year

The amount of total solids, combustible matter, and nitric acid has increased since the cold season of 1866

The chemical composition of this water shows that it is unfit for drinking purposes. Notwithstanding its bad quality, a large section of the Native community, many sepoys of the 25th Regiment, Punjab Native Infantry, and several European residents of Duriyagunge, drink it. The Natives believe that it is Jumna water, and the Europeans think the quality is excellent. I drank this water for some time in 1866, without being fully aware of its badness. Its effect on me was the production of dyspeptic symptoms and a tendency to diarrhoea. As soon as I had ascertained by analysis the quality of the water, I ceased to use it

The Medical Officer of the 25th Punjab Native Infantry says — "The canal water is of fair quality, but that obtained from Khyrattee Gate Well is bad. I have observed an increase in the number of Delhi sores when the canal supply was stopped, and also a tendency to spread in those sores that were healing"

Delhi Gate Well — This has been constructed in high ground inside the city wall. It is situated on the side of a much frequented high road, on either side of which is a row of houses, a peepul tree spreads its branches over the well. Around the well shaft is a masonry trough to catch the spilled water, but there is no drain to carry it off, at times the collected water is of a dirty brown colour, and is offensive to the smell, perhaps from the dirt and animal matter derived from the bodies and clothes of those who bathe on the well platform.

Since the analysis of 1866 was made, there has been a great increase of total residue, combustible matter, and nitric acid, the water now contains over 59 grains per gallon of their most objectionable forms. The permanent hardness arises from 5.07 to 7.73 degrees of Clarke's scale

This water is unfit for drinking, it is of worse quality than that obtained from the notorious cholera-producing well in Broad Street, Golden Square, London, and, at this season, R. D. Thomson. Of the 44 analyses made by him of the waters from the Marylebone Wells, in no instance was there so large a total residue, and only four waters contained a greater quantity of combustible matter than the Delhi Gate well supply.

The old Cantonment well is sunk in a large plain, formerly the parade-ground of the Native Infantry. It is at a considerable distance from any trees or buildings, and far away from any sources of contamination, the sides of the well are covered with a luxuriant growth of *algæ* or *confervæ* (I am not certain which) below the water-level. There was no vegetable growth in this well in 1866

The total solids found in this water have slightly increased, and the amount of earthy salt has considerably decreased, the total and permanent hardness have both diminished, and the combustible matter is present in slightly larger quantity than it was in 1866

The deep wells examined were only two, *viz*, the Indaree and the Kazee-ka-houz

Indaree Kooah — This is situated in the Kuroojapool Bazaar close to the road-way. It is covered by a large peepul tree, and is surrounded on three sides by houses, numerous pigeons live in the well, the water is much esteemed by both Hindoos and Mahomedans

The quantity of total solids, combustible matters, and earthy salts, as ascertained by two analyses, made at different seasons of the year, are very moderate and uniform in this water, and although it contains a rather large amount of lime and magnesian salts, *viz*, 23.50 grains per gallon, more than one-half of this quantity exists in the most harmless form, as carbonates of lime and magnesia dissolved by an excess of carbonic acid

The uniformity in composition of the water at different seasons, and the depth of water in the well, lead to the supposition of the supply being obtained from one of the lower water-bearing strata

Pigeons live in this well, and although not productive of much harm, they cannot possibly do any good, their absence would be preferable to their presence.

The *Kazee-ka-houz* well is in the heart of the city, situated in a triangular space formed by three roads. It is surrounded on all sides by houses which are densely populated. Within one angle of this plot is the well, and at another, is a masonry tank which is now regularly filled with canal water

Last year, the water from this well was only partially examined. The total hardness was then 9.84°, and the permanent hardness 9.0° of Clarke's scale, it contained about 45 grains of nitric acid per gallon. Ammonia and nitrous acid were found in it, the total residue and the combustible matter were not then determined

An analysis according to the scheme was made this year. The total hardness was 4.2°, and the permanent hardness 4.03° of Clarke's scale. Only one grain of nitric acid per gallon was found, and a small quantity of ammonia and nitrous acid. From these sparse data, it is evident that this water has undergone an astonishing change of composition since last year

In 1866, the distribution of canal water over the city was limited, as the aqueducts were being repaired or altered, the tank by the side of this well was empty, and at this time the water in the well must have been derived from drainage.

After the completion of the repairs, &c, the canal water again flowed in its former channels, and some wells, which were known to be very saline, were filled up by flooding them with canal water, allowing as much to run in as the level of the supply channel would allow. The pressure of such a large bulk of water appears to have caused rapid percolation into the earth, and, after two or three days had elapsed, the water in the wells usually resumed its former level, and it was found to have lost its saline taste, or, if not entirely deprived of it, a repetition of the treatment with canal water has usually, it is stated, attained the desired result.

I have not witnessed the treatment, my information was obtained orally from a Canal Officer and from Natives

On drawing water from the Kazee-ka-houz well this year, I observed that it was slightly opalescent, whereas in 1866, it was bright and colourless. I enquired how this change had come about, the people replied that their pet water had been spoiled some six weeks previously by the well being flooded with canal water, which had been run in by order of the Municipal Commissioners. The masonry tank was at this time full of canal water

The Kazee-ka-houz water is now nearly similar in composition to that of the Jumna. The sample analysed contained, however, slightly less of total residue, and about twice as much combustible matter, also a small quantity of nitric acid, nitrous acid, and ammonia; these did not exist in the Jumna water. The addition of the latter impurities and increase of combustible matter is readily explained, as the people, who live on the canal banks, wash their clothes and bodies, and bathe, and water cattle and horses in the stream

The rapid rate at which the water flows in the canal causes erosion of the banks, so that the water on reaching Delhi has a dirty ochre colour from the finely divided clay which is held in suspension.

In spite of the assertion made by some of the people that many persons were drawing been spoiled by the introduction of canal water, I observed that many persons were drawing it. Owing to its opalescent tint and flat taste, it was doubtless far less inviting and pleasant than the clear brisk and agreeably tasted water which the well contained in 1866, the pleasant qualities which it then possessed were derived from the presence of nitrates, and from the large quantity of "carbonic acid gas"

Her Majesty's 79th Highlanders has paid great attention to the filtration of water, in fact, greater care or solicitude for the efficient performance of this important process could not have been manifested by any corps.

I have, on two different occasions, taken samples of filtered water from the barrack-rooms and hospitals occupied by the Artillery and the 79th Regiment, the water was taken from the same filters in both instances, the results are given in the Appendix

During the hot season (June), the filters simply separated a portion of the suspended matters, and at the same time they added organic matter to the water in a small but appreciable quantity

After the commencement of the monsoon, the water was examined for the second time, the results of filtration were variable, in five instances the organic matter had decreased, in one instance it had been increased, and in one it was present in the same quantity that existed before filtration

No dependence can be placed on filters which give such variable results, the construction and arrangement of them is so unscientific that little benefit can be expected from their use

It may not be out of place to point out the shortcomings of the present filtering apparatus. Three earthen gurras are insufficient, four are required, for since one vessel is used as a receiver of filtered water, the remaining two must form the filter, one containing the charcoal and the other the sand, or the sand and charcoal are mixed together, and placed in the middle gurrah, and the upper one remains as the receiver of the bulk of water from the mussuck. Both arrangements are objectionable, for if the charcoal be placed in the upper vessel when the water is poured in, part of the charcoal is disturbed and floats, and the water does not pass through a compact layer of charcoal, but it passes between the fragments, and little, if any, good results, if, on the other hand, the charcoal and sand be mixed together on cleaning the filter, it is impossible either to separate the charcoal which requires to be re-heated to burn off the organic matter which has been absorbed, or to wash the sand thoroughly before re-placing it.

A good filter might be made of galvanized sheet-iron, with sand, charcoal, and vitrified brick packed in layers, supported by intervening diaphragms of metal, each being pierced by holes adapted to the nature of layer of the filtering medium which it is intended to support, in the hot season these vessels might be surrounded by a felt or other non-conducting jacket

The advocates for the use of porous gurras as filters maintained that the evaporation from the surface of the vessels cools the contained water to some extent two conditions are necessary for this, viz, permeability of the pores of the vessels, and movement of the air in contact with them. In barracks neither of these conditions exist as a rule, for the pores of the gurras are soon choked, and new vessels are seldom supplied, and owing to the position which the filter stands usually occupy in a corner of the verandah, scarcely any current of air reaches them, in many instances, the wind before it could reach the filters would have to describe the half of a circle

The water used by the troops at Delhi during the past year has been obtained from two sources, viz, the River Jumna and the Putthur-Ghatti Well, the 2-25th Royal Artillery has used the water from the latter source, and the European Hospital also obtains its supply of water from this well

The Wing of Her Majesty's 79th has drunk and cooked with river water since arrival. After the monsoon set in, the quantity of silt in the river water was so great that its use was discontinued temporarily. Owing to the want of iron-tanks in which the water could be allowed to remain at rest while the suspended matters subsided, the filters became choked, the water which passed through was in small quantity, and it contained so much earthy matter that the men did not like to drink it

If the river water is to be drunk by the troops at Delhi, iron-tanks must be used for storing it, while the suspended matters are precipitating

A Normandy's condensing apparatus has been put up, but the men object to the water, as it is very flat and does not quench the thirst, it was not worked during my stay at Delhi

Meerut—The Meerut waters, which were examined and reported on by Dr Sheppard at the end of last rains, were examined this year in April and May by Dr Gage. Dr Sheppard considered the water-supply ample and good, and Dr Gage's Report is to the same effect. Though Dr Gage examined the wells during the driest season of the year, he found from 15 to 40 feet of water in all, and the water held in solution only a very moderate amount of dissolved constituents. Dr Gage remarks upon the presence of nitric acid in the water of the Royal Artillery Hospital well, the well is in close proximity to the hospital buildings, and in a position of possible danger.

The water-supply of Meerut, though ample, and so far as chemical analysis can inform us, good, is yet open to the same objections that must always apply to the use of wells free to all comers

Dr. Gage found the filters both in hospital and barracks working well. He remarks, however, that the filters do not seem to him at all sufficiently protected from the intrusion of substances floating about in the air.

Bareilly—The waters of Bareilly were examined by Dr Gage in May and June, before the commencement of the rains. The station is supplied entirely by wells, the supply is ample, and is generally considered very good. It appears from Dr Gage's analyses that, with but one exception, the well water contains a very moderate amount of dissolved constituents, one as little as 9.5 grains to the gallon, but the wells appear to be very objectionable, situated in respect of their close proximity to buildings. The exception I have alluded to is in the case of the Royal Artillery Hospital well, which here, as at Meerut, and in other stations, appears from the analysis to become contaminated owing to its proximity to the hospital building. In the case of this well, the signs of contamination are so decided that, unless further examination should show a difference between the soil of the locality of the hospital, and that of those parts of the station in which the other wells are dug, they must be accepted as proving it. With regard to this and the well in the compound of the Infantry Hospital, Dr Gage writes—"Here, as at Meerut, the only wells in which nitric acid could be detected in any quantity were those connected with the hospital, and also the very close proximity of the different buildings connected with the hospital, and also the custom which the Native servants have of washing themselves around the well, which must, in time, add a considerable amount of animal matter to the soil. I would recommend that all wells, and more especially those for the supply of water to hospitals, should be sunk at a distance of about 100 yards from the nearest building, and also that no Native servants be allowed to go near the wells, except the bheesties, and that no washing should be allowed near them. The spilled water also is not properly removed from these wells, simply falling into a small trough at the side where it becomes stagnant, and, being left unemptied, runs over and soaks into the ground about." The state of things described by Dr Gage is quite sufficient to account for the large amount of nitric acid, of total solids, and of chloride of sodium present in the water of the well in question

Regarding the hospital filters Dr Gage writes as follows—"These filters are on the standard plan as supplied to all Regiments. The mouths of the vessels are quite open and unprotected from dust and floating particles, and it is said that the bheestee, to save himself the trouble of getting up to pour the water into the top-most vessel, or in some cases to lift it down, being placed at such a height that it is impossible to get up to it, pours the water into the lowest vessel. This would be entirely prevented by covering them in, and the height also might be made lower than at present both by decreasing the distance between the vessels which is in some cases much more than a foot, and also by slightly altering their shape. It would be a great improvement if some means were introduced for withdrawing the waters from the bottom instead of from the top, thus always ensuring the change of the bottom water which is not the case at present, a small hole drilled in the vessel, with a hard wood plug has been tried in a few cases, and has been a great improvement"

I think it may be concluded from Dr Gage's Report that Bareilly is amply supplied by nature with good well water, and that by a proper choice of sites for the wells, and a proper system of conservancy in connection with them, the troops there would obtain as good and safe water as "mussucks and dhols" can afford

Agra—The Agra waters were examined by Dr Jameson in December 1866, and were re-examined this year in April and May by Dr Cameron. The waters appear to have undergone but little change during the time that elapsed between the visits of these gentlemen to the station. The Cantonments are supplied with water for all purposes from wells, which yield an ample supply of water, but its quality, as taken from various wells differs very much, in the case of only a very few wells can it be said to be even fairly good. All the well waters of Agra contain nitric acid in more or less quantity, but I do not believe that this is owing to anything like sewage contamination of either the soil or of the water in the wells, for the soil itself over that District of country contains nitrates, and there is every reason for believing that, under favourable circumstances, such as the soil and climate of Agra present, nitrification may freely occur, though all matters that could in any way be brought under the denomination of sewage may be altogether absent. Still, even in Agra or in any other nitre-producing District, if we find nitric acid in what may be called abnormally large quantity in any one water, we may very reasonably suspect that it is being polluted

It is unfortunate that both the analysts who have visited Agra have sent in exceedingly brief reports upon the general question of the water-supply to the troops, and I cannot learn from them whether the supply is wholly drawn from the wells which have been already analysed and reported on. It is quite possible other water sources may be in use, and may need examination

The best of the waters in the Infantry lines is that taken from No 75 well, it contains 30 grains to the gallon of dissolved constituents, no ammonia, nitric or nitrous acids, this well, the deepest in the station, is 79 feet in depth. The next best water from the Cantonment wells is that of No 76, this well is 71 feet deep, the water is reported to contain both nitric acid and ammonia. The water of the wells Nos 77 and 79, each 61 feet deep, is not nearly so pure, and I think the use of these wells should be abandoned for drinking purposes in favour of wells numbered 75 and 76. The difference in the composition of these waters may depend upon the difference in the respective depths of the wells. Probably, if a well, 100 feet deep, were dug in the vicinity of well No 75, covered in, and provided with

a lift pump, it would yield an abundant and good supply of water, sufficient for the drinking purposes of the whole Regiment. All the wells just mentioned are apparently favourably situated in regard to their distance from buildings.

Dr Cameron has not particularly reported upon the water in use in the hospitals or barracks, but he expresses his opinion that the method of filtration in use is faulty, and that it rather increases the proportion of dissolved constituents, probably, as he thinks, from the sand and charcoal being kept too long in use.

The Artillery, as I understand Dr Cameron's Report, rely for their supply upon the "Mottee Kooah," but he does not explicitly state this. The water of the Mottee Kooah appears to be the best of the well waters of Agra, but it is a public well, much resorted to by the natives, and the water is therefore liable to accidental contamination.

I cannot, from the reports, discover the source of the water-supply to the troops in the Fort. I only learn that they to a slight extent use the water of a well situated just outside the Fort. It is a shallow well by the side of a small public tank which dries up in the hot season. Such a neighbourhood is in itself fraught with danger, and the well is a public one, its water is unquestionably bad, and its use should be abandoned.

Dr Jameson, when at Agra last year, examined well No 89 in the Native Infantry lines, and it was also examined this year by Dr Cameron. The well is 70 feet deep, it has no ridge to prevent water falling back into it, and is very largely used by the Sepoys and Camp-followers. The water contains a great deal of saline matter, 101 grains to the gallon, including a large amount of nitrates; the water is no doubt contaminated by the percolations from the Native lines, but the Sepoys like it, and they say it assists their digestion.

The water from the River Jumna was examined by Dr Cameron. It is considered by the natives the best water that can be had in the station, and such, from analysis, it appears to be, but the river is a long way from Cantonments, and could not, unless at great expense be used to supply them, nor is it needed in my opinion, for properly arranged wells, would yield a good supply. An artesian boring might greatly improve the water-supply of Agra.

Morar, Gwalior—This station was visited by Dr Cameron in June and July of this year. The station is supplied by wells of no great depth, from 30 to 40 feet, and, of those reported on, one-half run dry in the hot weather, and the water in the remainder is very low. Dr Cameron does not state if any scarcity results from the drying up of so many wells, or whether there are other sources of supply at hand to which the troops can resort. Neither does Dr Cameron report generally upon the supply for the Cantonment, either as regards its quantity or quality, but he states that the people entertain a bad opinion of the water, and that many wells in the city of Gwalior have had to be abandoned in consequence of their becoming salt.

The wells in Cantonments appear to be badly situated as regards their proximity to buildings. The water in every well contains ammonia, nitrous and nitric acids, and a rather large amount of oxidisable organic matter. Dr Cameron also states that the well waters contain sulphuretted hydrogen, some of them in considerable amount, but this, and other points connected with the water-supply, must be elucidated by an examination carefully conducted during next hot season. The water of the tanks in the Fort and of the Morar River were not examined.

At the request of the Brigadier Commanding at the station, Dr Cameron visited and examined the waters of a village in the neighbourhood of the Cantonments, and I copy his Report, as it presents a fair picture of the conservancy of a native village, and indicates the danger in which almost every station is exposed, however perfect its internal sanitation may be. It is to be feared we shall never be without cholera amongst our troops till an improved civilisation, spreading through the whole country, supports our efforts, by expelling the disease from its homes in such villages as that described by Dr Cameron.

"The village in question is inhabited by natives engaged in the manufacture of bricks, in the burning of which they use the refuse litter of the Cantonment of Morar. Large quantities of the refuse litter or dung are stored up in heaps in close proximity to the wells. The wells are all kutchas, and without platforms or other means of preventing substances getting washed into them from the dung heaps. They are all situated in a confined space measuring about 900 yards square. The soil through which they are sunk is of the same nature as that of the Cantonment. A slight epidemic of cholera prevailed in the village in the latter part of June 1867; 35 persons in all were affected, of whom 12 died, unfortunately the well, from which most of those affected procured the water, had been filled up by order of Dr. Morrice before my arrival.

"The analyses were performed subsequent to July 8th, and before the rains had properly set in, so that the water in the wells could not be much diluted. Amongst those using the water of No 6, there was one fatal case; No 7 is the Chamars' well, none of whom were seized with the disease. The well which was filled up was further removed from the dung heaps than any of the others. It was situated in the middle of a few native huts, being

distant about 5 yards from them, and on a lower level, so as to be exposed to having filth and human excretions washed into it.

No	Total hardness, Clarke's scale	Permanent hardness, Clarke's scale	Removable hardness, Clarke's scale	Grains of oxygen necessary to oxidise readily oxidisable matter in 1,000 grains	Total solids per gallon	Volatile matter per gallon	Mineral matters per gallon	Chloride of Sodium per gallon	Carbonate of Soda per gallon	Sulphate of Soda per gallon	Nitric acid qualitative reaction with Baume
1	4.5°	2.4°	1.4°	00091	51.45	5.89	45.57	8.47			Slight
2	4.15°	1.86°	1.73°	00181	42.91	4.2	38.71	18.9			Decided
3	6.2°	2.18°	3.3°	001705	45.15	4.76	40.39	4.27	11.45	5.78	Ditto
4	5.7°	.85°	4.2°	00277	49	3.64	45.36	10.5			Ditto
5	5.7°	1.68°	3.35°	001725	33.6	3.5	30.1	6.16			Ditto
6	6.45	4.16°	1.63°	00091	39.62	2.8	36.82	4.48			Ditto
7	4.5°	2.76°	.83°	00164	41.3	8.4	32.9	7.14			Ditto

"The amounts of chloride of sodium are much higher than in the Cantonment wells. The village in question is situated on the opposite side of the Morar River at a distance of about 1,000 yards from the 22nd Punjab Native Infantry lines. The average amount of chloride of sodium in two wells in these lines was 2.94 grains per gallon. There can be no doubt that the large amounts of chlorides and organic matter in the wells of the village are due to the near proximity of the dung heaps, and that their impurities have much to do with the access and propagation of cholera amongst the inhabitants."

Jhansie—Dr Griffith analyzed the Jhansie waters in June last. The station is supplied entirely by wells which are of various depths, from 30 to 40 feet, one only (No 11) is as much as 50 feet in depth. The wells are stated to be dug in alluvium mixed with granitic debris. The supply of water is apt to fail in the hot season, and is then supplemented by digging wells in the beds of the dry nullahs which traverse the station. People at the station unite in giving the water a good character for purity and wholesomeness, and Dr Griffith, looking to the results of his analysis, expresses a similar opinion. He says—"The waters at Jhansie are of very good quality. The supply is apt to become very little in the hot season, this is obviated by digging temporary wells in the channels of the dry streams which traverse the Cantonments. By this means abundance of water for the horses, bullocks, and satris is obtained, and what little water is afforded by the regular wells is reserved for drinking and cooking. Most of the wells are kutchas, and it would be an improvement if they were laid with bricks and mortar. The practice of the Natives of washing their bodies on the platforms of the wells is common here as at most other stations, it is very reprehensible and disgusting, for, in such of the wells as have no ridge, some of the water charged with organic matter from their bodies cannot be prevented from returning to the well. Cholera and other diseases may be introduced into, and propagated in, Cantonments in this manner."

The water of one only of the wells appears from its analysis to be decidedly bad, this is well No 10, in front of the Native Cavalry lines, the water contains a very much larger amount of dissolved constituents and of oxidisable organic matter than the other wells. There is no ridge round the mouth of the well to prevent the water running back, and as the well is largely used by the Natives, it may be, and probably is, defiled by the washings of their bodies. Further, Dr Griffith states the existence of two holes, 6 feet from the well, one of which was used to receive the mud lately cleared out from the well, and the other receives the filth of a neighbouring bungalow, such conservancy is hardly credible.

It is observable, as illustrating the effect of the manners and customs of the people upon the wells (though, indeed, this is even more strikingly shown by the state of the water of the bazaar wells) that wells Nos 9, 10 and 12, which are largely used by the Native troops, are more impure than those used by the Europeans, the probable source of contamination in the case of No 10 has already been indicated. No 9 is overhung by a large peepul tree, and numerous saucer-shaped depressions containing dirty water surround the well which is close to the Native lines. No 12 also has numerous depressions around it, and Dr Griffith notices the existence of a large Native privy, 50 yards from the well, but on a higher level than it. The water of well No 11 which is also used by Native troops, but which approaches in purity to that in the wells in the European lines, is a long way, 800 yards, from any Native hut, and probably on that account is not much frequented by the Native Cavalry, whose lines most nearly approach it.

The best of the wells reported on are Nos 6 and 8, which belong to the European Infantry. The wells are sufficiently distant from any buildings, and in their neighbourhood

there are no accumulations of filth, nor are there any saucer-shaped depressions which could retain dirty water, but the wells are not provided with ridges to prevent spilled water falling back into them

All the well waters reported on contain a notable amount of nitrates, but as Dr Griffith found nitrates in a specimen of soil taken from a locality free from any liability to artificial pollution, the nitrates in the well water need not be ascribed to the oxidation of sewage matters.

Saugor—The Saugor waters were examined by Dr Griffith in May 1867. The Town and Fort of Saugor are situated on a lake which receives their drainage. This lake is about 4 miles in circumference, its sides are of masonry, and are overhung with trees. The water of the lake is used by the inhabitants of the town, and by others living upon its banks for all purposes, and the water has, in consequence, lost its natural purity, and has become unfit for human consumption, yet the people drink it, and Dr Griffith reports that some people like the water, think it wholesome, and believe that it has the power of assisting digestion. The water is described as turbid, of a yellowish colour, having a sweetish taste, but a smell like that of decomposing vegetable matter. Analysis shows that it contains sulphuretted hydrogen, and a great deal of readily oxidisable organic matter, but it does not appear to contain a large amount of dissolved constituents. It would not, however, be right to form a decided opinion as to this or the other Saugor water from the results of the reported analysis, for Dr Griffith commenced operations at this station and met with difficulties there, especially in the use of the balance which render his results to some extent unreliable.

The European Infantry are supplied from a well about 100 yards from the barracks, the well is uncovered, and has no ridge to prevent the return into it of the spilled water. There are no deposits of refuse or filth in its neighbourhood, but Dr Griffith reports a tank at the edge of the platform in which water remains stagnant—"The well is 69 feet deep, and passes down through a dark coloured soil made up of disintegrated basalt and trap", it contained 12 feet of water at the time of Dr Griffith's visit. The water is very hard, and appears to contain a large amount of dissolved constituents. I suspect it is a very indifferent water.

The well which supplies the Artillery (No 3) is 47 feet deep, and contained 3 feet of water at the time of Dr Griffith's visit, the well is protected by a ridge, it has no platform, but a dry water-course carries away the spilled water. The water of this well appears to be better than that of the one just described. Wells Nos 8 and 2 aid in supplying the European troops; their water resembles that of No 3, No 8 supplies the Artillery Hospital. The European Infantry hospital is supplied by well No 15, which is situated close to the soldiers' gardens, the water is better than that of the wells already mentioned, but the supply from the well is very limited. The Native hospital is supplied from a well close to the Cavalry lines, the water resembles that of No 15.

There is a well in the Fort close to the lake, its water is reckoned bad, and is not used by the European troops quartered in the Fort, it is very probably fed by percolation from the lake.

Jubbulpoor—Dr Griffith analysed the water of Jubbulpoor in June, before the setting in of the rains. The station appears to be well supplied with water of very fair quality by numerous wells, which are, for the most part, dug at the top of the various little hills on which the barracks are situated. The water of the Nerbudda River is also used to a considerable extent by both Europeans and Natives, its water is very good, but, like all river water, needs filtration.

The wells are placed at a safe distance from buildings, and their conservancy is apparently good, except that they all need an encircling wall, and are, of course, exposed to danger from the resort to them of Native servants. Their waters appear to be good, but further examination of them, as of the Saugor waters, is needed to allow of their quality being fairly judged, the water of the station is generally considered wholesome.

There is, however, one well in the station, and that not an unimportant one, which is unquestionably very bad indeed, this is the well in the Native Infantry lines from which the Sepoys take their water, which, of course, they drink unfiltered. There are huts very close to the well, approaching it on either side at a distance of about six yards. The well, no doubt, more or less directly receives the washings of the bodies of the Sepoys, and a portion of other of their excretions, besides that of the skin, the water is reported to contain 93 grains to the gallon of solids, including a large quantity of nitrates. The Sepoys, though they consider the water bad, continue to use it, but a Sepoy will drink anything that comes out of a comrade's lotah, and their alleged precautions extend only, I believe, to the ceremonial, which is by no means co-extensive with the actual purity of the water imbibed.

Dinapoor—The Dinapoor waters were first examined by Dr. Durant in September of 1866, they were re-examined by Dr Jameson in May and June 1867, and again by Dr Jameson last month (September). Dr Durant considered the water-supply of the station very bad, and Dr Jameson's examination entirely supports that opinion. Dr Jameson agrees with Dr Durant in considering the hospital well, and the well attached to the cells, the best wells in Cantonments, and he ascribes their comparative purity to the fact of their being very near the river bank, and in the old bed of the river. When Dr Jameson examined the water of the well in the garrison cells in May last, he found it contained considerably more dissolved constituents than when it was examined by Dr Durant, but he thought this due to the well having been cleaned out just before his visit. When

re-examined last month, the water had almost precisely the same composition as when it was analysed by Dr Durant. This well is too close to the cells, and it has no platform, while the only means of escape for the waste water is through a groove in the ground leading to a large drain outside the cell enclosure.

The hospital well is situated between the hospital and the river, 22 yards from the former, and about 30 yards from the latter, on either side of the well, about 40 yards distant, are large latrines and urinals, and I think that, even at this distance, they may imperil the well water, especially as from Dr. Jameson's Report it appears that the water circulates very freely through the sub-soil. The well is partly covered by a wooden platform, on which the bheestees stand when drawing water, and Dr Jameson remarks, as did Dr Durant, upon the possibility of the well becoming infected by the washings from the bheestees' feet when they come barefooted to the well after traversing the hospital wards. The well yields an abundant supply, and as appears from the analysis of the water its constitution is very constant, and fair for well water.

The well of No 1, Permanent Barracks, is strongly commented on by both Dr Durant and Dr Jameson. It is 5 yards from the women's bath, 26 yards from barracks, 30 yards from two cook-houses, the spilled water lodges in the drain intended to carry it off, and 26 yards off is a drain in which water lodges, and into which the dirty water from the barracks is thrown. Dr Jameson writes—"This water is very bad, at the time of my visit the surface of the water was nearly covered with leaves, dust, &c, while a large number of frogs were swimming about in it. The ditch in front of the barracks was full of water owing to the river flowing back through the drains. Probably this ditch is one source of contamination, probably, too, there is some leakage from the plunge-bath. The well is also the natural drainage of part of the barracks, and of a couple of cook-houses. In front of the cook-houses there is usually a good deal of dirty water lying about." Analysis shows that the water is very impure, the Medical Officer in charge of the Regiment informed Dr Jameson that the water of this well caused diarrhoea and dyspepsia to those using it.

Well between Nos 13 and 14 Barracks—Dr Jameson writes, speaking of the water of this well—"It is only meant to be used for washing &c, but the barracks on each side are supplied with drinking-water from this source." The water of the well is very bad indeed, and Dr Jameson thinks this in part due to the ground about it being turned up for Soldiers' gardens, and in part to the fact that the greater part of the waste water finds its way back into the well, he thinks the well should be shut up.

Well No 3, Temporary Barracks—This well is 10 yards from a block of barracks, and 24 yards from a wash-house at the end of which is a latrine. The water of this well is said to cause diarrhoea and dysentery, it is evidently very impure.

The Artillery well supplies the Artillerymen and their horses. Dr Jameson says—"In the rains this well stands in the midst of mud and water caused by the horses being led to the well to drink. There is a small drain around the well where the water lodges. It is very dirty, too, containing two or three inches of mud. Formerly the horses were picketted 16 yards from the well, but they have now been removed to stables 40 yards distant from it." Dr Jameson thinks the water should be used for horses only, "for," as he says, "as long as the horses are led up to the well to be watered, the water cannot be expected to be good. Manure is carried on the horse's feet, more or less of it is deposited near the well, and most of this will find access to the water when rain falls, owing to the very porous nature of the soil." In the dry weather this water contained 39 grains to the gallon of dissolved constituents, including 56 grains of common salt, but when examined by Dr Durant, at the end of the rains of 1866, it contained 66 grains of solid matter to the gallon, including 11 grains of common salt, and at the end of the last rains the water held in solution 50 washes to the gallon of solids, including 10 grains of common salt, evidently, the rain-water washes a great deal of impurity into it. Most unquestionably this well should not be used to supply drinking-water to the troops.

Dr Jameson, during his last visit to the station, analysed the water of one of the wells in the Native Infantry lines, the well is reckoned the best of the command of the native troops, and from its position, immediately upon the edge of the River Soane, might be expected to contain good water. There is a masonry platform round the well, but no drain to carry away the waste water which collects round the edge of the platform, and sinks into the soil beneath it. The water contained, as reported by Dr Jameson, 68.5 grains to the gallon of dissolved constituents. Regarding this well Dr Jameson writes—"This water is stated to be the best in the 11th Native Infantry lines. The wells in the hospital command, and the two wells in the lines between the one examined and the hospital are stated by the Sepoys to be unfit for use. That there should be such an amount of solids seems incomprehensible, seeing that the well is sunk as near the river bank as it can be. When I visited the well I found a number of Sepoys washing themselves and their 'lotahs' at the well, all or a greater part of this water pisses again into the well through a small hole underneath the platform. A masonry ditch, 4 or 5 feet long, could carry all the spilled water into the river, and prevent this fruitful source of contamination. Cholera has occurred in these lines three times during the last three months. From its proximity to the river, I cannot help thinking this well ought to yield good water, a ditch ought to be made round the platform. I fancy the well stands in great need of cleaning out."

Bad as is the supply of water to the European troops at Dinapoor, that for the Native troops is evidently far worse. The well just described is between the west angle of the line and the river, and no doubt receives a portion of the drainage from the lines. I would suggest a well being dug on the banks of the river about 70 yards to the west of the old well, in the corner near the west boundary line of the Cantonment. The old well should be cleaned out and provided with a masonry drain as recommended by Dr. Jameson.

Dr. Jameson examined the river water both in May and October. In May it contained the gallon 11.9 grains of dissolved constituents, in October 14.3 grains, the increase being chiefly in the amount of soluble salts. The river water is infinitely better than that of any of the Station wells, and I beg to urge most strongly Dr. Jameson's recommendation to supply the station from that source. His report upon the water-supply of the station is as follows:—"With the exception of the well in the General Hospital, and that in the garrison cells, the water used by the troops is exceedingly bad. The constitution of the latter, too, varies considerably. In the hot season there were ten grains of solids in excess of the present amount, and this increase was due mostly to organic matter. That there should be great variation in the constituents of the water might be predicated. The surface of the soil is constantly falling in owing to the water underneath clearing for itself channels about a foot and a half below the surface. When the river was falling, streams of water, as thick as a man's arm, were pouring out of the bank a foot or two from the surface. If, therefore, the ground be turned up, or manure, &c., be deposited within the drainage area of a well, a large amount of foreign matter will gain access. It seems to me, therefore, that having wells at all in Dinapoor, is a mistake. It would not be a difficult matter to supply the Cantonments with excellent water from the river. If pipes were laid to a point 1 mile or so from the Church, and the river end of the pipe elevated a few feet, there would be plenty of fall. The water might be filtered, too, at the river, and be supplied to the barracks ready for use. I do not believe sinking new wells, or altering the old ones, will be satisfactory."

Hazareebaugh—The waters of this station were first examined by Dr. Durant in November last, and since then they have been twice examined by Dr. Thomson, first in the hot dry season of this year, and subsequently during the rains. The troops are entirely supplied with water for all purposes by wells which are of pretty uniform depth, about 37 feet, the wells are said to pass through a thin stratum of humus, and then through sand, clay, and granitic debris. The water from many of the wells is exceedingly good of the kind, thus the water of the hospital well contained in July last only 8.98 grains to the gallon of dissolved constituents, including but a small amount of volatile matters, only .67 grains of common salt, no nitric or nitrous acids, or ammonia, during the rains the water became slightly more charged with dissolved constituents, and was found to contain a little nitric acid. I may here notice a peculiarity in the well waters of Hazareebaugh, namely, that, while they contain (with the exception of those which are pretty plainly contaminated artificially), no nitrates in the hot weather, these salts are present in them during and after the rains. I conclude that the rains wash the nitrates from the soil into the wells. The hospital well contains rather a large amount of oxidisable organic matter, but this may be due to leaves and droppings of birds falling into the water from the tree which overhangs the well, this well, too, is used by the Natives, and may thence become slightly contaminated. I would most strongly urge the appropriation of this well for the sole use of the hospital, from which it is at a proper yet convenient distance, and to the supply of which the well even now is almost wholly devoted. The water in this well has never been known to fail, and if the well were enclosed, covered, and provided with a pump, the hospital would be ensured an excellent and never-failing supply of water.

There are other wells in the station also yielding excellent water. Indeed, owing to the nature of the soil, which is not of a kind to yield soluble matters, the water is far better than in most other Stations, some of the wells, however, are badly placed, too near buildings, and, therefore, liable to defilement, such is, I think, beyond a doubt the case of the well near the Racquet Court.

Unfortunately, though the quality of the obtainable supply is good, it is at present lacking in quantity, and it is reported that the Artillery horses have to be led away to distant tanks, in order that the supply from the wells may be preserved for the troops, and indeed in a very dry season the existing barrack wells may still further fail, and water must then be taken from private wells. Dr. Thomson mentions in his Report that, towards the end of the past dry season, there were complaints of the water having become physically bad, owing to the constant stirring up of the mud at the bottom of the nearly dry wells. Dr. Thomson's remark "that those possessing private wells have no complaint against their water, while each extols his own" is proof that good water is thought of, and valued in, the station, which would not be the case if it were plentiful.

Dr. Thomson reports upon two springs near the European Penitentiary about a mile from the barracks,—the water of these springs is good, but their yield small.

There are several tanks in the neighbourhood of Cantonments, all of which yield a perennial supply of water, and the water of the one examined by Dr. Thomson was, at the time of his examination, very good in most respects. It is said to draw a part of its supply from springs rising into it.

Dr. Thomson indicates, as a sight for a tank, a maidan just in front of the hospital barracks in proximity to the right wing buildings. The spot is sufficiently far from buildings, and on a higher level than most of the barracks, and probably a well-placed tank would

be the most successful and economical means for providing the troops with an ample supply of drinking-water. Additional wells might answer the same purpose, and if determined on should be well placed, not, as in the case of the new well alluded to by Dr. Thomson, in the neighbourhood of a public privy.

The bazaar well, the water of which Dr. Thomson examined, affords an excellent example of the artificial contamination of a naturally pure water, the water of this well, as compared with that of other wells, *e.g.*, the hospital well, is very hard, contains a very large quantity of readily oxidisable and volatile matters, much dissolved constituents including ammonia, nitrous and nitric acids, and about fifteen times the quantity of common salt that the soil yields to the uncontaminated well waters. It is satisfactory to feel that the report of the analysis of this well water, as compared with that of the other waters of the station, would infallibly have caused its condemnation, even though its site had not been known.

I subjoin extracts from Dr. Thomson's Report:—"The plateau, on the south centre of which Hazareebaugh stands, is situated among the Vindhya Hills in latitude 23° 59' north, and longitude 85° 24' east, at a height above the sea of 2,000 feet. Several small peaks rise above this plateau, the highest of which near Hazareebaugh itself are 3,000 feet above sea level. The mean temperature averages 66° F in the cold months, 85° in the hot, and 80° in the rains. The yearly rain-fall is from 60 to 90 inches."

The surface soil consists in most places of slight humus, in others it is sandy, or a hard clayey alluvium. Under the subjacent layers of sand, gravel and clay at the depth, in Cantonments, of from 20 to 40 feet, the rock is reached. The soil contains iron in small quantity. In the course of construction of a new wall in Cantonments, just in front of the Officers' barracks, a quantity of water had accumulated at the bottom of the excavation. Along with 90 grains per gallon of solids, much lime and chlorine, it was found to contain several grains per gallon of nitric acid.

The neighbourhood is comparatively bare of trees or underwood. No jungle of any consequence exists within 2 or 3 miles of Cantonments. The trees are either solitary or in small groups, and afford little shelter to the soil. Rice and other cereals are grown in spring and autumn. Tea grows very well. But the soil is in general of no great fertility, stunted grass and scraggy shrubs grow naturally.

The station depends for its drinking water-supply on wells. In constructing these it has been the custom to excavate the ground for a considerable area round the place destined to receive the shaft, the removed soils being again heaped in as the brick and lime-work advances. The drainage, consequently, of a considerable area, converges towards this point, both during the operations, and considering the loose nature of the re-placed earth, probably for a considerable time afterwards. In addition to these wells, two or three tanks exist to the northward of the station, but, as a rule, the water of these is only used by the Native population, and almost exclusively for ablution. In Cantonments the water for drinking and other purposes is supplied for the troops and sick from a dozen wells. There are also many private wells, the water of each being used by the inmates of the bungalow to which it is attached. There are about 16 bazaar wells, whose water is consumed by the Native population.

In general, even in moderately dry years, the water in the majority of the Cantonment wells diminishes very much in the hot dry weather, and sometimes subsides altogether. Recourse is then had for public supply to such wells, as either from their depth, or their being more in the direction of the water-shed, or on account of their water being in less demand, have been only partially exhausted. In the summer of 1866, much of the drinking-water of the troops was obtained from private wells, some of which were placed under guard. There is no account of any of those private wells having dried up. This year none of the wells had completely dried up, but the water in several of them, in the end of May, daily ran dry towards noon. The water in the well, which supplies the Artillery horses, became so scarce that the animals had to be led to a distant tank.

Of the bazaar wells some dry up, but in general there are no complaints that the water remaining in those which do not dry up is insufficient for the supply of the whole Native community.

Towards the end of the dry season there were complaints from many people that the water of the station had become physically bad. The deterioration may possibly be accounted for thus: the volume of water in the wells having considerably diminished, the mud at the bottom was constantly agitated in the act of drawing, and the water was thus rendered turbid. But none of the consumers complained that the water, after having once passed through their filters was objectionable as regarded either its colour, taste, or smell, and no evidence exists that they became subject from its use to dyspepsia, diarrhoea, dysentery, or any other disease likely to be induced by bad water.

In general those possessing private wells have no complaints against their water, and each extols his own.

Were it possible to have recourse to tanks for the water intended for ablution and washing, and to reserve that of the good wells for drinking and cooking purposes, it is probable that a more durable supply, and one commensurate with the demand in all seasons, might be ensured. The tanks which at present exist are, however, too far from Cantonments to be thus available. The construction of others would, therefore, be necessary. At present the number of wells in Cantonments is only equal to that of the barracks. The multiplying of these in different situations would, of course, increase the water-supply.

A greater quantity and better quality of water would be ensured by a regular periodical clearing out of the wells, when practicable, and by the provision of a uniform system of covering for their mouths. A closely applied disk of boarding perforated by a trap, the cover removable at pleasure, is all that is necessary. Every well in the station, except one in front of the hospital, lacks even this simple contrivance. Thus straw, leaves, and filth in any form, that may be conveyed by the wind, find easy entrance, and so cause deterioration of the water.

The sites of many of the wells have been injudiciously chosen, or rendered sanitariously objectionable after their construction. The well now being built in front of the Officers' barrack is 15 paces from a public privy. Others are in situations equally bad, some at the doors of washing-houses, or at the root of a large tree, or in the centre of a group of trees, or in a garden. One private well is in close relation to a tank of green putrid water.

The bazaar wells are sunk in the same soil as those in Cantonments on a somewhat higher level. They are generally situated at the side of a public thoroughfare, close to the houses or shops of the Natives. The water of particular wells is frequently used by only one sect of the community. The water of these bazaar wells is often used also on the spot, for the purposes of ablution, the bather sitting on the edge of the brick-work, so that much of the rejected water again finds ingress to the well.

Leather-buckets are used by the bheestees in drawing the water, by means of which the skin-bags, in which the water is dispensed, are filled, hence, probably, another source of contamination.

Station water is, as a rule, clear, colourless, and without taste or odour, one gallon of it containing from 8 to 20 grains of solid matters, somewhat less than half of which is soluble in water.

The water before being used by the troops for drinking is invariably passed through the barrack filters. These are faulty. They consist of two or three ghurrahs, one above the other. Into the upper ones are thrown sand and charcoal. The lower receive the water which has passed. The bottom of the upper vessels is perforated by a considerable hole, in which is placed a bit of brick, over which the water descends.

The effect of these filters is to deprive the water of its suspended matters, and to increase its deoxidising properties. They possibly cause no change in the quantity of mineral matter.

Fort William—The Fort is now entirely supplied with water for all purposes from the two tanks at the foot of the glacis. The tanks are large, and well kept and guarded. I examined the water of both in April last, and of the new tank again on the 17th September. Between the tanks is a masonry cistern which on the opening of sluice gates can be connected with both, or either tank, but before entering the cistern the water has to pass through a considerable thickness of sand and broken brick. On the occasion when I examined the water in September, the water from the old tank was shut off, and had been so for some days. From the cistern the water is raised by means of a pump worked by a steam-engine to a cistern on the ramparts, and thence it is distributed to stand pipes placed about the Fort. In order to raise the water to the level of the upper-storeys of the barracks, it is during a part of the day forced up a lofty syphon pipe, the level of which is above the level of the barracks. The tanks are filled partly by direct rain-fall, partly by percolation through the soil, but chiefly I suspect, by the system of surface drains which, spreading over the maidan, terminate in main drains leading into the tanks. These drains, at their entrance into the tanks, are provided with sluice gates, by means of which the entrance of the water can be prevented. It is evident that, if the water of the first rain-fall at the commencement of the rains was let into the tanks, it would carry into them, from the surface of the maidan, and from the drains, the accumulated dirt of the preceding eight months, and to obviate this, the system of drains is so arranged that the water is at first allowed to flow into the river, and subsequently, when it is concluded that the plain has been scoured, the water is permitted to fill the tanks. This arrangement is very good so far as it goes, but from an examination of the water taken from the drain towards the end of the rains, I find that an immense amount of sedimentary matter is carried into the tanks in addition to a considerable amount of dissolved organic matter, and I would here remark that, if this is so in the case of a well-kept and comparatively clean maidan, how much dirt must be swept by the rains into some tanks. So far as I know, the arrangement in the Fort William tanks for scouring the maidan is unique.

I suppose that, as a very large supply of water is needed for the Fort, it is necessary to reinforce the tanks by surface drainage, otherwise, it would be far better to adopt the plan in force at the General Hospital of allowing the tank to be supplied only by percolation and direct rain-fall. Might not the water in one of the tanks on the glacis be improved by making the other a settling tank, in which the water from the maidan drains should be allowed to stand in order to settle before being transferred to it?

At my suggestion a small well is being dug in the space between the two tanks, but as it had been only just commenced when the rains began, no satisfactory experiments could be made in comparing its water with that of the adjacent tanks. I am of opinion that, if a well in this situation is filled with sufficient rapidity from the neighbouring tanks, the intervening earth would form a natural filter, which would be very effective in freeing the water from suspended matter, and probably from dissolved organic matter also. I shall compare the water of this well with that of the tanks during next dry and rainy seasons.

The dissolved inorganic matter in the tanks is small in amount, and the water in the new tank is evidently improving. In September 1866 a gallon of the water held in solution 137 grains inorganic matter; this September I found that quantity was reduced to 77 grains. The water from the newly erected stand pipes in April last deposited a considerable sediment, chiefly of iron rust, but in September the water was clear. The water from the stand pipes now resembles that from the new tank in respect of its dissolved constituents, only containing a little less organic matter. The water is re-filtered in the barracks through the old style of filter. Great attention was paid to the filters during the time the 3rd Brigade of the Rifles garrisoned the Fort, and the filtered water was always, when I examined it, physically good, but the filters added slightly to the amount of oxidisable organic matter in the water. These filters should be disused, and either the Danchells or some similar filter should be introduced, or the whole of the water should be passed through animal charcoal before being distributed in the barracks. Unfortunately, as the water from the stand pipes is used by Native troops, it cannot, for general distribution in the Fort, be filtered through animal charcoal.

General Hospital—Both the General Hospital and the adjoining Military Hospital are supplied with water for all purposes from a tank situated under the east wall of the hospital compound. The water of this tank very closely resembles that of the new tank on the glacis, and, excepting that it contains a large quantity of oxidisable organic matter, is very good. The tank was formerly in part filled by surface drains collecting the water of the direct rain-fall, and by percolation only, but the surface of the compound slopes in some places towards the tank, and I suspect water drains directly into it. In connection with this subject, I think a very useful experiment might be tried on some conveniently situated tank to determine the quantity of water entering it during the rains by direct rainfall, and by percolation respectively, the edges of the tank being raised to prevent the entrance of any surface drainage. I suspect the tank would fill, and would fill with much clearer, and purer water than if replenished in the usual way, but to make the experiment a thorough one as regards not only the quantity but the quality of the water it should be made upon a clean tank, and not upon one which, like that in the General Hospital compound, contains the accumulated sediment of many years. This tank is not properly guarded, for I myself saw an individual washing at the edge of it, and doing so apparently as a customary thing. I would strongly recommend that the tank be raised round, and that its edges be raised, thus affording a reverse slope which would entirely prevent the entrance of the surface drainage.

Near the north-east corner of the tank, about 10 or 15 yards from its edge, is the latrine which is used by the sepoy of the Hospital Guard. It is upon the dry-earth system, and, when I visited it, was in an unexceptionable state of cleanliness, in fact, there was nothing in the atmosphere of the place to reveal its use. Immediately outside the entrance is a masonry drain, in which the men perform their ablutions, and which leads the waste water away outside the wall of the compound into a large drain. So long as the proper conservancy of this privy is preserved, it is hardly possible that it could become a source of danger to the tank, but in old times and under the old system the privy must almost necessarily have added pollution to the tank water. The worst feature in connection with the hospital tank is the large drain immediately outside the wall of the compound up to which the tank reaches. The drain in question is nothing but a deep wide ditch, the chief use of which is to carry off a part of the rain-fall from the maidan into Tolly's Nullah, but it serves a subsidiary purpose in acting as privy and general receptacle to the bazaar to the east of the hospital compound. I have no doubt that the tank drains any stagnant water from the ditch, and becomes contaminated by it. I feel sure the ditch would not have so long been allowed were it not that the compound wall hides it from sight.

By the tank ghât stands the filtering tower which will be presently described, and here the drinking-water is filtered prior to its being carried to the hospital, the water for cooking and for other purposes is taken from the tank in the usual way by the bheestees. In the hospital the water is drunk in the state in which it is taken from the tower filter, the bheestees filling the earthen-jars which stand in the hospital verandah, and also the water bottles which stand between every third or fourth bed in the hospital. These bottles are however, more commonly filled by the ward coolies, who make use of a tin-pot for the purpose, dipping it into the water-jar, a plan which has only the sanction of custom in its favour.

Barrack-poor—At Barrack-poor the troops, both European and Native, take their drinking-water from the Havildars' tank, a fine large tank on the parade-ground. The water of this tank, in its greatest state of concentration at the end of the hot dry season, contained only six grains to the gallon of dissolved constituents, of which 9 of a grain was volatile matter. Towards the end of last rains, after a heavy rain-fall, the water contained but 4.55 grains to the gallon of solids, of which 1.05 was volatile matter, but on both occasions it contained a large proportion of oxidisable organic matter. In May the water had a slightly earthy taste, and was of greenish hue. Yet, though the water, judging from its analysis, might be pronounced good, I believe in its present state the tank is not an altogether safe source of supply, for it is unguarded; and, though a railing extends partly round, it affords very insufficient protection. When I was there I saw two extremely dirty-looking individuals step into the tank, and take water with which they washed themselves on its edge. Further, the tank is in part supplied by a large drain, the gathering ground of which extends into the Infantry lines. About 40 yards to the east of the tank is a line of stables standing on

ground a little higher than the tank, the stables probably do no harm in the dry weather, but the first heavy fall of rain must sweep a considerable quantity of refuse from them, as well as much other dirt, from the gathering ground of the drain, I have mentioned, into the tank. The tank should be enclosed and guarded, and no washing should be allowed near its edge, and I think the edge of the tank should be raised so as to give it an outward slope. If it is necessary that the tank should be supplied from the surface drain, some arrangement should be made for directing the first washings of the ground into another course. I think it probable that a good filter would remove the greater part, if not all, of the organic matter which results from the decomposition of the vegetable debris present in the tank water.

The supply from the Havildars' tank is not completely sufficient for the troops, and it was stated to me that, despite the apparent chemical purity of the water in May, those using it at the time thought it bad, and, moreover, the supply was scanty. It is to be remembered that this tank is used by a large number of troops, as well as by camp-followers, and it is not therefore to be wondered at that the water runs low in the hot dry season, and, doing so, acquires an earthy taste and greenish color, and it would appear to be very necessary that the water-supply for the troops should be augmented, either by the use of wells, or by cleansing and enclosing one of the other numerous tanks in Cantonments. But might not the Havildars' tank be devoted to the use of the Native troops, while the water for the new European Infantry barracks might be taken from the main of the Calcutta water-works which runs close to them? The water could be pumped into a sufficiently lofty cistern to allow of its being supplied at high pressure to the barracks. For general purposes, the water might be used as taken from the main, while the drinking-water should be filtered in the several wards.

Underneath the north wall of the European Hospital, and close to the hospital buildings is a tank known as the hospital tank. The ground on which the hospital buildings stand forms a part of the gathering ground of the tank, while other buildings are also close upon it. Further, the tank is partly filled by the help of a large drain which enters its north-east corner, and has, as its gathering ground, the Native Bazaar. Thus situated, it is not to be wondered at that the tank-water is reckoned bad, and becomes, as it concentrates during the hot weather, quite undrinkable, it must be very liable to pollution. I was assured by the Medical Officers that the water of this tank is not used for drinking purposes, and the hospital steward, whom I saw when I visited the tank, confirmed this report, but he allowed that no guard was placed upon the bheestees, and that it was possible they might fill the hospital filters from this tank. The sirdar bheestee, who was sent with me to point out the Havildars' tank, informed me that the bheestees did supply the drinking-water for the hospital from the hospital tanks, and if his statement is correct, I can quite understand the presence in the filters of the horrible stuff which was taken from them, and sent to me for analysis—stuff such that I am sure no one but a patient in the delirium of fever could be persuaded to drink. There must always be danger in the use, in a hospital or a barrack, of two waters,—one of which is unfit for drinking, and especially when, as is the case at Barrackpore, the one tank is under the hospital walls, while the other is at a very considerable distance. Bheestees are just the kind of people to contrive to save themselves all the trouble they possibly can, and as, if found carrying the inferior water into the hospital, they would have the excuse that it was intended for the bath-rooms, they would very securely use it for the filters also.

Dum-Dum—The European troops at Dum-Dum are supplied with drinking-water from the Diglah tank, which is at a short distance from the barrack square. The water of the Diglah tank resembles that of the Calcutta tanks, but contains more dissolved constituents. The tank is entirely unenclosed and unguarded. During my visit I noticed several Natives washing upon its bank. The tank is filled by direct rain-fall, by percolation, and by surface drains. A very large drain opens into its north-east angle, and this drain, I was told, reaches away to a great distance, passing into the bazaar. I think that means are urgently needed to improve the conservancy of this tank, and I would suggest the following—That the open space around the tank (it is not very extensive) should be enclosed, and strictly preserved as the only gathering ground for the tank, all drains proceeding beyond it should be stopped, the ghât should be guarded, and no one should be allowed to wash in its neighbourhood. The water should be passed through an efficient filter before being used for drinking purposes.

Not far from the Diglah tank is the School tank, it is not now used by the troops, but is largely used by the inhabitants, and is considered very good water. When I visited the tank, I noticed many people taking water from it. In the centre of each of three sides of the tank and close to its edge are buildings which I took to be bells-of-arms from their symmetrical disposition, but which on enquiry I learned were privies. I give an analysis of the water of the tank, for it confirms what might be expected as to the impurity of the water, and serves to show the result of contamination in affecting the amount of solids in a water. The School tank is similarly situated as regards soil to the Diglah tank, and its water would no doubt resemble that of the Diglah tank, were it not that it is more decidedly open to contamination.

The European hospital is supplied by a well, known as the hospital well, it is situated on the edge of the maidan in front of the hospital, a road intervening. The water is carried to the hospital by bheestees. The well is used not only used by the European hospital, but for the Native hospital also; and when I visited it, Natives, apparently sepoys, were drawing water from it. The well is situated in a small enclosure, and I should say all the spilled water found its way back into it. When I was there, it was so surrounded by bogs and ditches

that it would have been necessary to bare one's legs to the knee to reach it. At a short distance about 20 yards from the well is a small and very dirty tank which is used for all purposes, including bathing cattle and washing clothes, the water in this tank becomes very small in quantity and very foul in the hot weather, and I should think that when the water in the well falls low, that from the tank would be very apt to drain into it.

I would recommend that the present wall, which encloses the well, be removed, that the well be provided with a properly constructed ridge and platform, that the ground around it be raised, and that the tank in the neighbourhood be filled up with broken brick. Another well should be provided for the Native hospital, and only the bheestees of the European hospital should be allowed access to the present well, of course a still better plan would be to provide the well with a pump.

Lucknow—Dr. Orton was appointed to examine the waters of the Cantonments of Lucknow, Seetapoor, and Fyzabad, during the last hot-season, but his duties as Assistant Sanitary Officer detained him in Lucknow, and he chiefly devoted himself, under the instructions of the Commissioner, to the examination of the waters of the city wells. Dr. Orton did, indeed, examine some of the wells in Cantonments, but, under some misapprehension, only the condemned wells which are not in use by the troops. His Report, therefore, throws no further light upon the water-supply of the Cantonments than that obtained from Dr. Bonavia's Report, but I think the Report is well worthy of consideration, for Dr. Orton has been at great pains to make it complete as regards the water-supply to the city, and incidentally it represents very fairly the dangers to which the water-sources of the country are very generally exposed.

Dr. Orton examined the water of the River Goomtee, taking it at a point a quarter of a mile above the city. The water is far better than that of any of the station wells which have as yet been reported on, and it would be a great boon to the city if it were supplied from the river by a pipe, which might also supply the Muchi Bhawan Fort and the New Fort. The water of the Muchi Bhawan is evidently very bad indeed, and it is most necessary that a wholesome supply should be provided for the use of its inmates.

Allahabad—The waters of this station were examined by Dr. Milne in November and December 1866, and again during April and May of this year.

The troops are entirely supplied with water for all purposes from wells which yield an ample supply of water, the water from all the wells is of very uniform quality, and for well water fairly good. The wells appear to be advantageously placed as regards distance from buildings, but an objectionable feature in connection with some of them is the existence of a trough for watering cattle placed by the side of the well.

Dr. Milne analysed the water from the Ganges and Jumna Rivers, the former is evidently far the purer of the two.

Since writing the above, I have received the Report of Dr. Compigné, who was engaged in analysing the Allahabad waters during a part of September and October last. Dr. Compigné examined two of the public wells of the station, and also a well in the new Cantonments, the waters of these wells closely resemble those of the wells analysed by Dr. Milne, and re-examined by Dr. Compigné.

Dr. Compigné mentions in his Report that the analysis of the waters of the old Cantonments is, perhaps, of little consequence as they will shortly be deserted, the troops moving into the new Cantonments. The water of the well in the new Cantonments might be pronounced good, if it were not for its degree of hardness which is greater than that of a thoroughly good water, but the hardness may, perhaps, be increased, owing to the presence in the neighbourhood of the well of much lime in use for the buildings in course of erection.

The well, however, if I rightly understand its position, is too near to the barracks, and another well should be provided to supply drinking-water to the troops. I think a position for the drinking-water well should be chosen between the north end of the new barracks and the river, but not in the line of drainage, and the well should be at least 50 yards distant from any building. I believe that a properly constructed and guarded well in that position would, on the whole, yield a supply preferable to that which could be derived from the river, for the river water, though comparatively very pure as regards its dissolved constituents, becomes loaded with finely divided siliceous matter at the commencement of the rains, and this could only be separated by allowing the water to rest in tanks for subsidence during several days. Filtering apparatus might be put up near the well, and from it the filtered water should be supplied, on the constant system, to the barracks.

Cawnpore—The Cawnpore waters were examined by Dr. Jameson in September and October 1866, and by Dr. Milne in April, and again in May 1867.

The troops are entirely supplied from wells. The wells have a pretty equal depth from 60 to 70 feet, and they yield an ample supply of water, but there appears to be considerable difference of opinion as to its quality. The more general opinion appears to be that the quality of the water is not good.

Well No. 15 appears to be one of the best, there is no indication from analysis of its suffering any sewage pollution, but it has a high degree of permanent hardness.

Well No. 19 contains, according to Dr. Milne's analysis, nitrates, and I suspect, from the very large amount of volatile matters, a larger quantity of these salts than the analysis represents, it also contains a large amount of chlorides.

Well No 7 contains a large amount of nitrates and chlorides. Well No 9 is stated not to contain nitrates, but I cannot help thinking, from the large amount of volatile matters, that the nitrates may have been overlooked. I regret Dr Milne did not examine the soil in some place not accessible to pollution, in order to determine whether these salts naturally exist in it, and to what extent.

I cannot but think the wells must be liable to pollution, for they are almost all badly placed as regards proximity to buildings, thus No 13 is within 15 yards of a cook-house, and 20 yards from a lavatory. No 19, 12 yards from a latrine, and about the same distance from a store-house. No 3 has latrines on either side at a distance of 20 yards. No 9 has lavatories at 9 yards' distance. No 7 is distant 12 paces from a lavatory. Further, the wells marked Nos 9, 15, 19, and 7 are reported as being provided on either side with a trough to which cattle are brought to drink, and the waste water from these wells is allowed to sink into the neighbouring soil. I think a great objection to these drinking troughs for cattle in the neighbourhood of wells is that they bring to the well a number of the lowest and dirtiest class of Natives, and thereby expose the well to contamination.

I believe that there is great necessity for re-arrangement of the water-supply for the troops at Cawnpore, and that wells for drinking-water should be provided at a distance from buildings, and should be guarded from use by all but the bheestees attached to the barracks.

Since writing the above I have received the Report of the analysis of the Cawnpore waters which were made by Dr Compigné in October and November. I can only identify one well water analysed by him with any analysed by Dr Milne, and that is the water of No. 7 Well.

Dr Compigné writes—"The Cawnpore waters are of interest and consequence as regards quantity there is quite sufficient, as regards the quality, the permanent hardness is too high, the total solids and volatile matter are both high, as also the mineral matter, the chlorine is also in some amount. Owing to my having had some idea of being sent in charge of the 12th Bengal Cavalry, the examination was necessarily made in a hurried manner, and some points which were omitted, I must send the information of as soon as I receive it."

From the foregoing account of the water-supply at various stations, some general considerations may, I think, be usefully drawn as regards the peculiar dangers to which the water-sources under consideration are liable, and the means which should be taken to prevent their occurrence, and first, as regards the water-supply from wells. The well-water may be unwholesome owing to the nature of the soil of the water-bearing stratum from which it is supplied, for, independently of all sewage pollution, this may contain so much saline matter, or saline matter of such a nature, as to charge the water percolating it to a degree which renders it unfit for consumption, and in this case the supply can be amended only by sinking the wells till a more favourable water-bearing stratum is reached.

Then, in other places, though the water in the wells may naturally be very good, the soil being of such a nature as to yield a minimum of solid matter to the water percolating it, yet the supply may become polluted by the neighbourhood of latrines, urinals, collections of filth, or animal or vegetable refuse, or, perhaps, to a less degree, by the proximity of cook-rooms, wash-houses, and other buildings. Another source of danger of the same kind, and one very common to this country, is the proximity to the well of a dirty tank, such as is probably used for washing clothes, and bathing animals of all kinds, including man, sometimes the most dangerously dirty of all the water in the tank becomes in the hot weather very low, and horribly foul, yet so long as it holds water it will aid in feeding the supply of the neighbouring well.

Wells belonging to hospitals seem to be very liable to contamination, it may be from the drainage of the surface on which the buildings stand, but it is not to be wondered at that proximity to any buildings in India should influence the water of a neighbouring well, for the multitude of native servants who are employed, always finding an open door or a window handy, will throw refuse of any kind out upon the ground. The perusal of the analyst's reports puts it beyond a doubt that many of the wells on which they have reported are very dangerously placed, and such wells should, I think, be disused, even though the analysis of their water fails in bearing definite evidence against them, for while an immense mass of evidence goes to prove that contaminated water is a positive cause of disease, it cannot be said that science in the present state of chemical analysis is always able to detect the poisonous matters in the water, and therefore liability to contamination is the point first to be considered in judging of the fitness of a water for human consumption.

The causes of contamination that I have mentioned are those to which wells in all countries are, to a greater or less extent, subject, but the peculiar habits of orientals give rise to sources of contamination which do not exist in European countries. Thus when a native comes to a well, he does so to wash as well as to drink, and probably the first thing he does, will be to sit on the edge of the well with his legs dangling into it, draw some water with his lotah, or, if he is poor, with any old tin-pot improvised for the occasion, wash his mouth, face, hands, and legs, and after this, having taken a drink, he goes about his business, unless it strikes him that his cloth is unusually dirty, when he will wash that too, and even if all this is not done over the well, it is done by its side, and the washings find their way, but by an indirect route, back to the well. Then to some of the wells, cattle are brought to be watered, and with them come their attendants, dirty to a degree, and just having issued from a foul stable, or more filthy hut which they may be occupying with a cholera-stricken companion. Where they have been sitting, a friend or the bheestee throws down his pot or his water-bag,

or rests his mussuck, and dirt which adheres to these implements in all probability goes down into the well. Or it may be the bheestees or the servants, fresh from traversing with their naked feet the cholera ward of hospital, stand upon the edge of the well, or on the wooden platform over it, and as they draw the water, the droppings wash the dirt from their feet into the well beneath.

If, as I believe is undoubtedly the case, the wells are liable to contamination from such circumstances as those I have mentioned, it is necessary that certain rules should be laid down, and acted upon, for their construction and protection. First of all, it should be decided, from the results of experiment upon the waters of existing wells, to what depth a new well should be sunk to ensure a constant, and, as far as possible, naturally pure supply of water, and in deciding on the position of a new well intended to supply drinking-water, a distance of 40 or 50 yards from any building, or drain, or badly kept well or tank, should be insisted on. In regard to the construction of the well, it should be what is ordinarily called a "pucka" well, and the masonry should rise above the level of the ground or platform at least two feet, forming an encircling wall to the well mouth, and the wall should be surrounded by a masonry platform at least six feet in breadth on every side, and terminating in a drain which should lead the waste water away from the neighbourhood of the well. Unless a pump is used, the water should be raised by means of a windlass provided with a chain and metal bucket, and lastly, the well supplying drinking-water should be strictly guarded, and none but the bheestees should be allowed access to it. But what a waste of labour and time does this method of drawing water involve, and how much safer and better in every way it would be to have none but covered wells, each provided with a pump, instead of the open wells, worked as now with the windlass, or the simple rope and leather bag, and the saving of labour is perhaps a small consideration in comparison with the security from pollution which the less primitive plan would confer. No doubt the day will come when a still further advance will be accomplished, and the barracks throughout the country will be supplied, as are those in Fort William, by means of pipes laid on to the building and kept supplied on the high pressure system by means of machinery.

Tanks—Tanks are largely used in the Lower Provinces as reservoirs of water, but not nearly to so great an extent in the Upper Provinces, where the use of wells predominates. The water of the tank, like that of the well, varies in purity with the nature of the soil in which it is dug, but is not so much affected by this cause, as a great part of its supply is derived from the direct rain-fall. Besides direct rain-fall, the sources of the supply to a tank are surface springs, percolation through its sides, and the water which is collected and poured into it by surface drains.

Tanks are liable to be polluted by the same causes as are wells, and they are more difficult to guard, but then water, unless artificially contaminated, is generally more pure than that of neighbouring wells. In the case of a tank which is in part fed by surface drains, great attention should be paid to the direction the drains take and to the nature of their gathering ground. If, as in some cases, this is a bazaar, it is evident that the water which flows into the tank must be horribly impure, loaded with much of the debris of the filth which has been accumulating upon the ground during the eight or nine previous months. In the case of some tanks, as for instance those which supply Fort William, it is perhaps necessary, in order to fill up the tanks, to collect the water by means of drains from a large extent of mardan, but when this expedient is necessarily resorted to, the first washings of the ground and drains should be permitted to escape in another direction, and only when the ground has been thoroughly washed should the surface water be led into the tanks. If there be two adjacent tanks, one should be made a settling tank, in which the water may be allowed to clear prior to its being led into the other tank. In the case of a very large supply of water not being needed, it would be well, as has been lately done in the case of the General Hospital Tank, to close all surface drains, and to allow the tank to fill, as far as can be, by direct rain-fall, and by water, which percolating through the soil is filtered and made to undergo a certain amount of oxidation, and the banks of the tank should be provided with a reverse slope by raising the edge a foot or two above the level of the surrounding ground. The tank of drinking-water should be fenced round and guarded, and no one, excepting the bheestees, should be allowed access to it, but it would be far better that the bheestees also should be excluded, and that they filled their water-bags from cocks supplied by a filter as at the General Hospital.

Filters—From whatever source the drinking-water is taken for barracks and hospitals, it is ordered to be passed through filters before use, a very necessary arrangement, for the water, as it is brought by the bheestees, almost always contains a considerable amount of suspended matter. This is especially the case with tank water during the rains, and even during the dry season the water is apt to become muddy, owing to the bheestees and others stirring up the mud at the ghât while filling the water bags, or taking water for their own use. Well water suffers in the same way, for, disturbed by the constant agitation of the vessels let down into it, the suspended matter cannot subside, and if the water is low, the mud at the bottom becomes stirred up.

The filters now in use in all the barracks and Military hospitals are on one pattern, consisting of three earthen-jars supported on a stand one above the other, these jars are half filled with wood charcoal and sand, and each is pierced below with a hole through which a tag of linen guides the water as it filters into the mouth of the vessel next beneath, from the third vessel the water falls into another usually of a larger size in which it is stored for use.

and from which it is taken by means of a pot of some sort dipped into the jar. A row of such filters stands in the hospital or barrack verandah, or in the wards themselves. In one hospital I have seen them placed immediately outside the cholera ward, four or five yards distant from the beds.

The objection to this form of filter are very numerous, in fact, the plan is bad in every way —

- 1 —The vessels are all open, and not only do insects and dust—the sweepings of the ward—fall into them, but they are free to receive the germs of disease which may be floating in the barrack-room, or more especially in the hospital ward, while the water must absorb a portion of any noxious gaseous emanations present in the air.
- 2 —The organic and other matters suspended in the water collect in the ghurrahs, especially in the upper one, and there decomposing and becoming soluble, add to the amount of soluble organic matter already present in the water, indeed, unless the filtering material is very frequently changed, and the vessels each time are well cleansed, this may become a very serious evil. As the vessels are porous, it is difficult to cleanse them thoroughly.
- 3 —The water is removed from the lower vessel only by dipping a pot into it, and either the pot or the hand may, and very frequently will, soil the water, especially if ward coolies are employed, but further, the water is only occasionally changed, and the sediment which sinks to the bottom of the storage vessel must slowly contaminate the residual water, which, in its turn, infects the fresh water dropping in from above.
- 4 —The filtering medium is bad,—in fact useless unless for removing the coarser suspended matters.
- 5 —The trouble that is necessary in cleansing the filters and changing the material, is such, that the work is often too long neglected.

These are no fanciful objections to the present description of filter, they must appear obvious to any one who will give the matter a little serious consideration, and the reports which I have received from the analysts concerning the filtered water they have examined, proves them real. Almost always, as a rule, the filtered water contains more organic matter than the water from the source, and the water in the upper vessel more than either. The water in the upper vessel was in many cases found to be swarming with musquito larvæ, and other animalcules, and has been described as filthy stuff. Musquito larvæ and other animalcules are very commonly present in the water of the lower vessel. The water from a storage vessel, which I examined, had so strong a smell of a muskrat that I feel sure one must have fallen into it.

The present filters are indeed so manifestly bad, that the wonder is they have been so long retained.

The requirements of a good filter are as follows —

- 1st —That it should deliver an ample supply of water.
- 2nd —The arrangement of the filter should be such, that the suspended matters in the water may not collect upon the filtering medium.
- 3rd —The filter should not, as any part of its arrangement, contain an open receptacle, exposing the water to the air of the chamber in which the filter is placed.
- 4th.—The means for drawing the filtered water should be by a cock.
- 5th.—The filtering medium should be readily removable.
- 6th.—The filtering medium should be altogether, or in part, well burnt animal charcoal; perhaps the only substance with which we are acquainted which can, to any great extent, remove dissolved organic matter. Regarding the use of animal charcoal as the filtering medium, I quote the following remarks from extracts of letters from Dr Frankland, which are published in the Registrar General's Report for 1866 —“I should prefer filtration through animal charcoal, which, as you will see from my three recent reports, removes practically all organic matter, one-half ton of animal charcoal would be required for each 1,000,000 gallons sent out daily. The animal charcoal should be in grains about the size of blasting powder, and the filtered water would simply have to pass through the mass of this charcoal contained in a suitable tank. The London Water Purifying Company, between the entrances to King's College and Somerset House, use this material, and it is through one of their filters that the new river water passes for my monthly determinations. I think, after all, that such a mode of purifying the whole of a Company's water is, by no means, an insuperable undertaking. The charcoal will continue to act for six months at least. It is the charcoal used by sugar-refiners, and care should be taken that it is fresh, and has not been already used.”

There is indeed another substance, namely, the so-called magnetic carbide of iron for which the inventors claim the property of separating organic matter from water, but the power of the magnetic carbide to do so has been questioned, and moreover the expense of purchasing and bringing out to this country the magnetic carbide in sufficient quantity would be an objection to its employment when that is put in comparison with the use of animal charcoal, for animal charcoal is a substance which might be prepared quite as readily and as cheaply in this country as in England, and besides its powers may be renovated by simply subjecting it to re-combustion. It is indeed to me a matter of surprise that the use of animal charcoal has not been long since introduced for the filtration of the water in hospitals and barracks, for its value has been over and over again established by the experiments and observations of the best authorities on the subject, and it alone (excepting perhaps the magnetic carbide) of all filtering media can do more than remove the suspended matters. No doubt, animal charcoal will not remove all the organic matter from impure water, it may not be able to remove the cholera poison, whatever that may be, but its purifying effect is unquestionably so great and it is so readily applicable, that in my opinion it only remains to decide as to the form of the filter in which the charcoal should be used.

The only filter I have seen, or read of, which combines all the requirements I have mentioned above, is the so-called Danchell filter, which is now in very large use by the London Filtering Company, and is, as I hear, being fitted on a large scale to the Government Asylum at Broadwood in England. The principle of the filter is very simple, it may be described as a syphon, the shorter limb of which is expanded into a chamber packed with animal charcoal, the larger limb of the syphon is fitted with a stop cock through which the water is drawn off as required, and there is an arrangement by means of which the rate at which the water filters through the charcoal can be increased or lessened. The charcoal in the chamber can be easily removed, and the chamber re-packed with fresh charcoal, or with the old, after it has been re-burnt. The filter may be placed in any cistern, but a zinc or iron cistern commonly supplied with the filter. The filter is supported in the cistern at a short distance from the bottom, and only the comparatively clear water comes into contact with the gravitate to the bottom, and only the comparatively clear water comes into contact with the filtering medium. I think the filter might be still further improved, especially if the water to be filtered is very muddy, by placing it in a cistern divided by a partition, on one side of which the filter should be placed, while the other side should be fitted with a tray of sand above which the water should be poured, and through which it would consequently have to pass before reaching the filter itself. The sand upon the tray should be changed every or every other day. It is essential to remember that the purifying power of animal charcoal depends upon the property it possesses of condensing oxygen upon its surface, and it is therefore necessary that the charcoal should be frequently exposed to the air in order that it may absorb a fresh charge of oxygen. This, in the case of the Danchell filter, can be managed.

The Danchell filter not only fulfils all the requirements I have mentioned, but it has this additional advantage that its syphon-like construction enabling it to draw the water through the filter, aids gravitation in keeping up a constant filtration, and further, as it keeps the filters full throughout, nothing can enter without first passing the filtering medium. Danchell's filters in a covered cistern should be placed in every hospital and barrack ward. The prices of the filters, as advertised by the Company, are as follow —

	£	s	d
"Filter No 1, yielding $\frac{1}{2}$ a gallon per minute	1	10	0
" " 2 " " 1 " "	2	0	0
" " 3 " " 2 gallons "	3	0	0
" " 4 " " 4 " "	4	10	0

One of these filters has been in use for about a year in the Medical College Hospital, and I subjoin the results of some experiments I made, with a solution of permanganate of potash, with a view to testing this filter, and comparing it with the ordinary ghurrah filter which is working side by side with it in the Hospital, both filters are supplied from the same source, a tank in College Square. At the time of experiment, the Danchell filter was delivering three quarts per minute, the charcoal in it has never been changed, probably if it had, the results would have been still more strongly in favour of the Danchell filter.

Quantity of permanganate solution (2 grains in 20,000 added to 10,000 grains of the water acidified with 30 minims of sulphuric acid, to obtain a color permanent during 15 minutes)

	Grains
Water from the tank	160
Water from the upper ghurrah of the old fashioned filter	170
Filtered water from the ghurrah beneath	210
Water from the cistern of the Danchell filter	190
Filtered water from the Danchell filter	50
Distilled water as received from the Medical Store	55

Department

There are now several of the Danchell filters in Calcutta, and doubtless one could easily be obtained for trial in any Government Hospital, should Government entertain the idea of using this filter upon a large scale.

At the General Hospital, the whole of the drinking-water is filtered by the side of the tank, and undergoes no further filtration in the wards. The filter is thus constructed. By the side of the tank stands a circular masonry tower, the interior cavity of which is 15 feet high by 10 feet in diameter. The top of the cistern is dome-shaped, and the arch of the dome is 5 feet in height. The lower 2 feet of the tower is blocked up with masonry, above this is a cistern 2 feet in height, the roof of which is of perforated paving stones, and on these rests the filtering medium—first, 8 inches of coarse broken brick, then as much fine broken brick, above this 2 feet of fine sand. The water is pumped into the tower by a Californian lift-pump, half an hour's pumping suffices for 24 hours' supply. The filter is provided with a gauge which shows the amount of water in it, and the daily consumption. In October, about 300 people consumed 210 gallons daily for drinking only. The water for cooking and washing is taken direct from the tank.

The water is drawn from the filter by means of four stop-cocks, the pipes from which enter the tower upon its floor, and the cocks are 2 feet above the level of the ground, below each cock is placed a sloping board upon which the bheestee rests his mussuck while filling it. The spilled water is carried off by a masonry drain which surrounds the tower, and carries the water into the hospital drains which lead to the outside of the compound. This filter has now been working constantly for nearly a year, the water from it is perfectly clear, bright, and tasteless, and 10,000 grains of it acidified with sulphuric acid, consumed only 90 grains of permanganate solution. The water from the tank consumed 190 grains, and that from the upper compartment in the tower, 200 grains. This filter would be much improved by placing a layer of animal-charcoal 2 feet in thickness between the sand and the very finely broken brick, and I think that the top of the tower, instead of being dome-shaped, should be flat and covered by two iron-flaps. The filter should be cleared out once a year, but as it is at present constructed, this could be done only by taking down the masonry dome. The objection to the use of such a filter, as the one just described is, that the water has to be carried from it to the wards in the bheestees' water-bags, and it must be stored there, and may be placed in an open and otherwise unfit vessel. The small filter in each ward would, it seems to me, be a very preferable arrangement. I think it should be the rule as regards all filtering arrangements either that the water should be filtered by the side of the tank or well, and should then be distributed at high pressure over the barrack or hospital, or that it should be filtered in the wards through such a filter as the Danchell's, but on no account should there be any storage of filtered water in open vessels, especially if it is required for use in the wards of a hospital or barrack.

It is evident from the reports that have been already received from various stations regarding their water-supply that the supply is not so guarded as to prevent the risk of its infection by the poison of cholera, and of other diseases, and the question arises, in what way may this occur under the circumstances that have been described? It seems probable that water may become the propagator of cholera by disseminating cholera excreta which have found access to it, and this has, I think, been abundantly proved by the investigations of Dr. Snow and others who have followed in the same path of inquiry. Certainly, if the evidence, these investigators adduce in support of their view is not absolutely conclusive, it is sufficiently strong to make it reasonable to act as if it were so, in considering the arrangements for the supply of water to a very important section of the community. So strongly, indeed, is this opinion held by some high authorities on the subject that, in a leading article published last year in the *Medical Times*, the writer says—"So that the occurrence of a single case of cholera on the banks of the Thames, the sea, or any other obscure river from which the London water-supply is derived, may, at any moment, diffuse the cholera all over the Metropolis," and, if this be a true statement of what may occur from the mingling of cholera discharges in even a very minute quantity in drinking-water, the present mode of supply to our troops must be full of danger. And the danger is the greater, because neither chemical nor microscopical research can detect the poison even though it be present in fatal quantity, and further it is most unquestionable that the means at present employed for the removal of the poison are worse than useless. Whatever this poison may be (whether living matter of a low sort, as Dr. Beale holds, or matter in a state of change as Liebig supposes, or as Dr. Richardson has still more recently surmised, an alkaloid), if it be placed in pure well-oxidised water, it will more or less quickly decay and vanish, and, I believe, much would be accomplished towards this most desirable end by passing and infected water through animal-charcoal, for this method of filtration may destroy the poison by causing its oxidation, and if it should not effect this, yet it would certainly so purify the water from organic matter that the poison, if of the nature of living matter, would probably die for want of pabulum. But though it is not possible either to detect the cholera poison in water, or with certainty to remove it if it be present, there is much comfort in the consideration that by the use of properly placed and protected wells, and by delivering the water upon the constant system, avoiding its exposure by storage or otherwise, we altogether prevent, or, at any rate, reduce to a minimum the danger of contamination. On the other hand, if the wells for the supply of drinking-water are dug in unprotected ground, if we leave the wells uncovered, and allow them to be indiscriminately frequented by servants and passers-by, if cattle, with their attendants, come to water at them, if all frequenters may wash themselves and their clothes by the well-side, while for the purpose of drawing the water they may use any utensil they please, and if no means or very inadequate means be taken to prevent the return of the fouled water to the well, then we do, indeed, increase the risk of contamination to a very great degree, and perhaps bring it to a maximum when we expose the water in the hospital wards in an arrangement which might more justly be called an infection trap than a filter.

Then, again, water may become a propagator of cholera, if contaminated by sewage, the sewage either containing the germs of the disease, or, when received with the water into the alimentary canal, serving as a congenial soil in which any germs happening at the same time to find their way, there can vivify and increase. Whichever view be adopted, it may now be laid down as an indisputable fact that sewage received into the alimentary canal is a very potent agent in the production of cholera, and this though it is in a very diluted state. Indeed we can readily understand that if the poison putake into a system in which matter, no amount of dilution will render the water to which it finds access innocuous, the dilution only diminishing the chances of the poison being received into a system in which it can find the conditions necessary to its development and increase. There is this to be said regarding a mixture of cholera poison and sewage, that though we cannot, by any test, detect the one, we can, with a very considerable degree of certainty, recognise the presence of the other, and even though the sewage may be present in very small amount, we can, by the use of proper means, establish such a probability of its existence as is abundantly sufficient to act on. For sometime past, reliance has been placed on the use of permanganate of potash for the detection of sewage matters in water, the permanganate affording and indicating the amount of oxygen necessary to destroy the putrescible matters present there, and, though this test has been disparaged by Dr. Frankland, I cannot but still place much value on its use. Dr. Frankland's objection to the test is that the permanganate has little or no action upon such bodies as sugar, gum, gelatine, hippuric acid, urea in solution, but then it is to be remembered that these bodies are much higher in the scale of organic products, and of a much more stable nature than the putrefying, changing matter into which excreta are resolved when exposed to the action of air, and moisture, and soil. It is a fact that, under such circumstances, sewage does largely yield readily oxidisable matter, which is quickly acted on by permanganate of potash (hence our use of that substance as a deodoriser), and I, therefore, still believe that the permanganate test is not only a ready, but a very valuable means of detecting sewage impurities in water, only its results must not be taken alone, for it is no doubt a fact that water may decompose a large amount of permanganate owing to its containing readily oxidisable organic matter of a comparatively harmless nature. In such a case as the following, the indications of this test must be taken of great importance. The physical properties of the well waters of a station are alike, and may be unexceptionable, but one of the waters consumes much more permanganate than the others, in such a case we may, I believe, be very confident that the well is somehow or other contaminated, and the suspicion will be increased almost to certainty if it is found that the well contains ammonia, nitrous acid, or nitrates or chlorides, or still more, two or all of these, in excess of the amount present in the other wells. The permanganate test may indeed fail owing to a cause different from that which I have mentioned above, for as at Delhi, though the soil may receive an immense amount of sewage, yet its oxidising power may be so great that none but the products of the complete oxidation of the sewage, namely, nitric acid, may reach the well water, and doing so indicate not the present pollution, but the habitually pollution, should a direct passage be open for the sewage by any chance, but then in this case the presence of an amount of nitrates far in excess of that in the wells of extramural Delhi indicates very clearly what is occurring.

As a very decided proof of the ability of the means we are now employing to detect impurities, especially sewage, in water, I would adduce the comparison of some of the Hazarebaugh well with the well in the Bazar at the same station. The circumstances of the wells are precisely the same excepting that this one well is surrounded by a bazaar, and the record of the analysis of its water is such that any sanitarian would at once have pronounced the water polluted, though he had no knowledge whatever of the site of the source whence it had been taken. And though the allowed imperfection of our means, and some times want of care or ability on the part of the analyst may cause a failure in the labours of an impure water, I am satisfied that very valuable results will accrue from the detection of the present analytical commission, both in the way of the detection of unwholesome water sources, and of possible causes of pollution. Of this I am assured that there is much bad water in use by our troops, both European and Native, and that there has been a lamentable want of foresight in the disposition of tanks and wells, or of new buildings in proximity to old water-sources, but these things were done before the experience and investigations of the past few years had shown that bad water, and now that we do recognise this relationship, there is no excuse for the man, official or non-official, who digs a well near a privy, or empties his refuse into a pit beside his house well, or leads the washings of a bazaar into the tank from which drinking-water is supplied. Such a procedure is almost criminal in its carelessness, and since we know by the bare suspicion of such contamination should be at once acted on, and impossible to obtain necessary measures.

No 184, dated 9th July, 1868

Office Memo from—COLONEL H. W. NORMAN, C. B., Secy to the Govt. of India, in the
Mily Dept.,

To—Secretary to the Government of India, P. W. Dept.

The undersigned is directed to forward to the Secretary to the Government of India, in the Public Works Department, the accompanying Report by Dr Macnamara, on the water analysis, during 1867-68, at the several large Stations in Bengal, with the view of precaution being taken to prevent the pollution of wells in Cantonments which are used for drinking-purposes, so far as may be practicable, and also to the adoption of such measures as may appear to be feasible for sinking new wells where it may be found desirable.

2 His Excellency the Governor General in Council is also of opinion that where river water is available, it will be worthy of consideration whether arrangements should not be made for a tentative use of such water.

3 Special attention is requested to the remarks on the Dinapoor water at pages 12 to 14 of the Report.

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MILITARY WORKS

R. No. 92 PUBLIC WORKS

October 30 1868

7 Dec / 68

Enclosure one.

Dec 200

Ms 200.22 in Jan'y 1869

Forwards, for information and guidance, copy of a Report by the Chemical Examiner to Government, on the analysis of potable waters of Cantonments, and requests that the suggestions therein contained may receive the most careful attention.

little on water

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11-12
 Fort St George
 22nd June 1845

Communicate to the Secy of Treasury for
Attention —

29 March 1882-1884

no 4764

Govt. of {1868} Madras.

PUBLIC WORKS.

To The Supr. Engineer

&c, &c, &c

Dated

For'd

Encl. /

G O. 22nd July 1869 No. 200

No. 398-299

Water - Circular
on the Govt of Madras
regarding for attention, copy
of a Report by the Chemical
Examiner to Govt on the
analysis of Water of Can-
-onment, forwarded to the
Supr. Engineer